Estimating the Max Capacity in Work Zone Area

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1. Introduction

There are different definitions of capacity at a work zone area. For example “Hourly traffic volume under congested traffic conditions” or “Hourly traffic volume converted from the maximum-recorded five minute flow rate” or “Flow rate at which traffic behavior quickly changes from uncongested conditions to queued conditions” or “Flow just before a sharp speed drop”.

Our objective in this project is Estimating max capacity in work zone area and we have two capacity definition, “Max throughput” and “Flow rate at which traffic behavior quickly changes from uncongested conditions to queued conditions. (Traffic volume immediately before queue begins)”.

2. Survey Data Analysis

A Survey has been done in September 2007 in 6 days at work zone locations. They used 4 camcorders to videotape the traffic volumes. I used survey data on September 6th. The specifics of this survey data can be found below.

- Weather: Nice and calm
- Location: I-95 NB near exit 32
- Number of Total Lanes: 4
- Number of Closed Lanes: 2
- Position: 2 right lanes closure

Figure(1). Location of Work Zone Area

The location of work zone area is shown in the Figure (1) and the geometry data is shown in the Table (1) and (2).

Location	Symbol	Latitude	Longitude
1st Lane Taper Start	A6	39 8.786 N	76 50.559 W
1st Lane Closure	B6	39 8.914 N	76 50.470 W
2nd Lane Taper Start	C6	39 9.135 N	76 50.306 W
2nd Lane Closure	D6	39 9.236 N	76 50.197 W
Camcorder1	CAM6 1	39 9.298 N	76 50.091 W
Camcorder2	CAM6 2	39 8.778 N	76 50.586 W
Camcorder3	CAM6 3	39 8.678 N	76 50.630 W
Camcorder4	CAM6 4	39 8.239 N	76 50.950 W

Table (1). Geometry Data

	Length (feet)
A6_B6	874
B6_C6	1548
C6_D6	790
D6_Camcorder1	627
A6_Camcorder2	102
A6_Camcorder3	725
A6_Camcorder4	3794

Table (2). Geometry Data

I used data of the camcorder 4 for input flow. We have the number of cars and trucks that pass the camcorder4 in each lane. I first calculated the 15min flow, then, I converted to one hour flow. (Table (3),(4) & (5))

Time	Lane 1		Lane 2		Lane 3		Lane 4	
	Car	Truck	Car	Truck	Car	Truck	Car	Truck
19:42:15-19:57:14	317	0	327	20	253	64	212	19
19:57:15-20:7:14	291	0	249	20	236	33	177	21
20:12:15-20:27:14	200	0	174	11	139	38	240	19
20:27:15-20:42:14	136	2	135	19	132	31	239	18
20:42:15-20:57:14	152	1	131	23	132	34	199	21
20:57:15-21:12:14	162	7	150	16	153	40	206	27

Table (3). 15min Input Flow

Time	Lane 1		Lane 2		Lane 3		Lane 4	
	Car	Truck	Car	Truck	Car	Truck	Car	Truck
19:42:15-19:57:14	1268	0	1308	80	1012	256	848	76
19:57:15-20:12:14	1164	0	996	80	944	132	708	84
20:12:15-20:27:14	800	0	696	44	556	152	960	76
20:27:15-20:42:14	544	8	540	76	528	124	956	72
20:42:15-20:57:14	608	4	524	92	528	136	796	84
20:57:15-21:12:14	648	28	600	64	612	160	824	108

Table (4). 15min Input Flow Converted to One Hour

Time	Total Cars (Converted to One Hour)	Total Vehicles (Converted to One Hour)	Percent of Trucks	Percent of Vehicles in Lane1	Percent of Vehicles in Lane2	Percent of Vehicles in Lane3	Percent of Vehicles in Lane4
19:42:15-19:57:14	4436	4848	0.085	0.262	0.286	0.262	0.191
19:57:15-20:12:14	3812	4108	0.072	0.283	0.262	0.262	0.193
20:12:15-20:27:14	3012	3284	0.083	0.244	0.225	0.216	0.315
20:27:15-20:42:14	2568	2848	0.098	0.194	0.216	0.229	0.361
20:42:15-20:57:14	2456	2772	0.114	0.221	0.222	0.240	0.317
20:57:15-21:12:14	2684	3044	0.118	0.222	0.218	0.254	0.306

Table (5). Input Flow for the Model

3. Simulation of the Work Zone Area with CORSIM Software

I used the geometry data and input data from survey analysis to build the CORSIM model. The geometry of the model is shown in the Figure (2) and the model geometry data is shown in the Table (6).

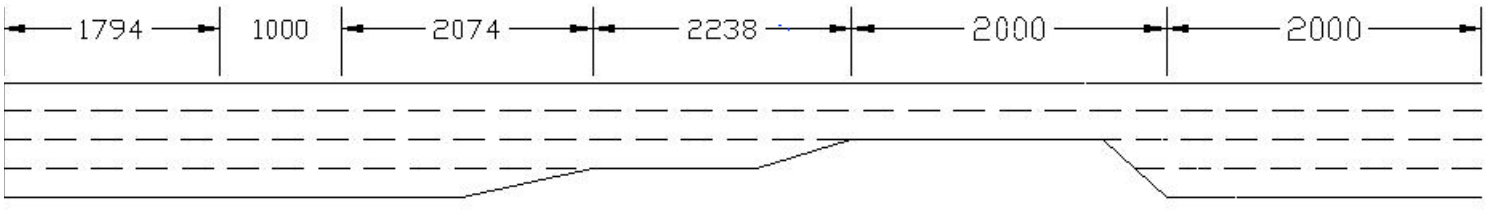


Figure (2). Geometry of the Model

Link#	1	2	3	4	5	6
Length (ft)	1794	1000	2074	2238	2000	2000
Number of Lanes	4	4	4	3	2	4
Number of Dropped Lanes	0	0	1	1	0	0
Number of Added Lanes	0	0	0	0	2	0
Distance for Added or Dropped Lanes from Upstream Node	-	-	1874	2138	1980	-

Table (6). Model Geometry Data

4. Calibrate the CORSIM model to get similar results as real case data

For getting better results for the base case, I changed the Vehicle Entry Headway from Normal Distribution to Uniform Distribution and Erlang distribution with a=1. The best results for the base case obtained by using Erlang distribution with a=1. Therefore, I used this distribution for vehicle headway in my modeling.

For calibrating the model, I changed 3 parameters one by one and checked the CORSIM outputs with the survey data. These three parameters are:

- Free flow speed
- Rubberneck factor
- Car following factor

Also, I used the camcorder 1 and camcorder 3 data and also the queue length to calibrate the model.

The base case specifics and also the CORSIM output for camcorde1 and camcorder3 locations and queue length is shown in the Table (7), (8), (9) & (10).

Link#	1	2	3	4	5	6
Free Flow Speed (mil/h)	65	60	55	55	55	65
Rubberneck Factor(%)	0	0	0	0	0	0
Car Following Factor(%)	100	100	100	100	100	100

Table(7). Base Case Specifics

Location(Camcorder1)			
Time	Number of Vehicles		Error Percent
	Corsim Simulation	Survey Data	
20:12-20:27	917	864	6.1
20:27-20:42	889	842	5.6
20:42-20:57	881	838	5.1

Table(8). Camcorder1 Location Comparison for the Base Case

Location(Camcorder3)			
Time	Number of Vehicles		Error Percent
	Corsim Simulation	Survey Data	
19:42-19:57	1154	1171	-1.5
19:57-20:12	832	938	-11.3
20:12-20:27	742	741	0.1
20:27-20:42	735	746	-1.5

Table(9). Camcorder3 Location Comparison for the Base Case

Queue length from the transition start point			
Time	Corsim Simulation (feet)	Survey Data (feet)	Error Percent
20:17	2490	7006	-64.5

Table(10). Queue Length Comparison for the Base Case

For the best case, Camcorder1 location data is acceptable but camcorder3 location data has one error more than 11 percent. The most important problem here is the queue length. So, I changed the mentioned parameters one by one. First I changed the free flow speed. The changing

in output in camcorde3 location when the free flow speed is changed can be seen in the Table (11).

Location Camcorder3									
Time	Number of Vehicles (speed=55 , change in link 3 rubberneck)								
	Survey Data	r.n.=0	r.n.=10	r.n.=20	r.n.=30	r.n.=40	r.n.=50	r.n.=60	r.n.=70
19:42-19:57	1171	1154	1171	1073	1011	875	821	Veh. backed up	Veh. Backed up
19:57-20:12	938	832	850	853	896	849	778		
20:12-20:27	741	742	778	811	861	851	777		
20:27-20:42	746	735	698	711	716	788	760		
		Error percentage							
		-1.5	0.0	-8.4	-13.7	-25.3	-29.9		
		-11.3	-9.4	-9.1	-4.5	-9.5	-17.1		
		0.1	5.0	9.4	16.2	14.8	4.9		
		-1.5	-6.4	-4.7	-4.0	5.6	1.9		

Table (11). Camcorder3 Location Comparison for different Free Flow Speed

In the Table (11) it can be seen that the best results is for Free Flow Speed = 55 mile/hour.

For the camcorder1 location the results for all of these free flow speeds are good but the queue length is still the most important problem and it is much different from the real case data. So, the best free flow speed is 55 mile/hour and I chose this one.

Then I changed the Rubberneck factor in link 3, 4 and 5. The changing in rubberneck factor in link 4 & 5 did not give us good results. As you can see in the Table (12) rubberneck factor = 10% in link 3 gave the best results, so I chose this rubberneck factor for link3 but again the

big problem was the queue length.

Location(Camcorder3)									
Time	Number of Vehicles (speed=55 , change in link 3 rubberneck)								
	Survey Data	r.n.=0	r.n.=10	r.n.=20	r.n.=30	r.n.=40	r.n.=50	r.n.=60	r.n.=70
19:42-19:57	1171	1154	1171	1073	1011	875	821	Veh. backed up	Veh. Backed up
19:57-20:12	938	832	850	853	896	849	778		
20:12-20:27	741	742	778	811	861	851	777		
20:27-20:42	746	735	698	711	716	788	760		
		Error percentage							
		-1.5	0.0	-8.4	-13.7	-25.3	-29.9		
		-11.3	-9.4	-9.1	-4.5	-9.5	-17.1		
		0.1	5.0	9.4	16.2	14.8	4.9		
		-1.5	-6.4	-4.7	-4.0	5.6	1.9		

Table (12). Camcorder3 Location Comparison for Different Rubberneck Factor in Link3

Then I used this rubberneck factor for link3 and again changed the free flow speed to see which one is better when the rubberneck factor in link 3 is 10%. The results are shown in the Table (13) & (14).

Location(Camcorder3)							
Time	Number of Vehicles (in link 3 rubberneck=10%)						
	Survey Data	Speed=65	Speed=55	error	Speed=45	error	Speed=35
19:42-19:57	1171	1040	1171	0.0	1081	-7.7	1064
19:57-20:12	938	781	850	-9.4	934	-0.4	850
20:12-20:27	741	785	778	5.0	776	4.7	812
20:27-20:42	746	739	698	-6.4	719	-3.6	717

Table (13). Camcorder3 Location Comparison for Different Free Flow Speeds When the Rubberneck Factor in Link3 is 10%

Location(Camcorder1)							
Time	Number of Vehicles (in link 3 rubberneck=10%)						
	Survey Data	Speed=65	Speed=55	error	Speed=45	error	Speed=35
20:12-20:27	864	925	892	3.2	932	7.9	959
20:27-20:42	842	897	900	6.9	898	6.7	909
20:42-20:57	838	880	836	-0.2	738	-11.9	749

Table (14). Camcorder1 Location Comparison for Different Free Flow Speeds When the Rubberneck Factor in Link3 is 10%

It is seen in the Table (13) & (14) that the speed =45 & 55 gives good results in camcorder3 location but in camcorder 1 location the 45 mile/hour speed has one error about 12%. Therefore, I chose the 55 mile/hour for free flow speed. Again the queue length was the big problem.

Then, I changed the Car Following Factor in link 3, 4 & 5. Changing this factor in link 4 & 5 did not give good results, so I only bring the results for changing this factor in link3. (see the Table (15) & (16))

Location(Camcorder3)									
Time	Number of Vehicles (speed=55 and in link 3 rubberneck=10%)								
	Survey Data	C.F.F=120	error	C.F.F=140	error	C.F.F=150	error	C.F.F=160	error
9:42-19:57	1171	1051	-10.2	1005	-14.2	1047	-10.6	968	-17.3
9:57-20:12	938	834	-11.1	927	-1.2	931	-0.7	922	-1.7
0:12-20:27	741	835	12.7	937	26.5	927	25.1	892	20.4
0:27-20:42	746	768	2.9	747	0.1	753	0.9	839	12.5
)ueue(feet)	7006	5706	-18.6	5806	-17.1	5756	-17.8	6279	-10.4

Table (15). Camcorder3 Location and Queue Length Comparison for Different Car Following Factors

Location(Camcorder1)									
Time	Number of Vehicles (speed=55 and in link 3rubberneck=10%)								
	Survey Data	C.F.F=120	error	C.F.F=140	error	C.F.F=150	error	C.F.F=160	error
20:12-20:27	864	931	7.8	983	13.8	973	12.6	921	6.6
20:27-20:42	842	874	3.8	917	8.9	914	8.6	947	12.5
20:42-20:57	838	878	4.8	695	-17.1	694	-17.2	797	-4.9

Table (16). Camcorder1 Location Comparison for Different Car Following Factors

In the Table (15) & (16), it is seen that the best queue length is for C.F.F =160 in link3, but the camcorder1&3 location data are not in acceptable range of error. Because the queue length in this situation is the best one I could find so far, I decided to choose this C.F.F for link 3 and change the rubberneck factor in the links to get good results for the camcorder1 & 3 location data.

After changing the rubberneck factor in link 3, 4 & 5, I also checked the combination of them. In addition, I used the changing rubberneck factor by time in a link. The situation of the best results is shown in the Table (17).

Link#	**1**	**2**	**3**		**4**	**5**	**6**
Free Flow Speed (mile/h)	65	60	55		55	55	65
Rubberneck Factor(%)	0	0	10	50	2	0	0
Time of Onset(sec)			300	900	1500		
Car Following Factor(%)	100	100	160		100	100	100

Table (17). The Model Parameters for the Best Results

It is seen in the Table (17) that the Free Flow Speed is the same as the base case and the Car Following Factor is 160 for link3 and 100 for other links. The Rubberneck Factor is zero in all links at the beginning but after 300 sec (5-min) it changes to 10% in link 3 and after 900 sec (15-min) another 50% Rubberneck Factor is added to link3. Furthermore, after 1500 sec (25-min) the Rubberneck Factor in link4 becomes 2%.

The results of this situation are shown in the Table (18) & (19).

Location(Camcorder3)			
Time	**Number of Vehicles for the Best Situation**		
	Survey Data	**CORSIM**	**error**
19:42-19:57	1171	1087	-7.2
19:57-20:12	938	847	-9.7
20:12-20:27	741	766	3.4
20:27-20:42	746	739	-0.9
Queue Length (feet)	7006	6119	-12.7

Table (18). Camcorder3 Location and Queue Length Comparison for the Best Situation

Location(Camcorder1)			
Time	**Number of Vehicles for the Best Situation**		
	Survey Data	**CORSIM**	**error**
20:12-20:27	864	790	-8.6
20:27-20:42	842	775	-8.0
20:42-20:57	838	787	-6.1

Table (19). Camcorder1 Location Comparison for the Best Situation

In the Table (18) & (19), it is seen that the results have acceptable errors.

5. Estimating the Max Capacity

I used 9% truck percentage (the same as survey data) and 25% of input flow in each lane and changed the input flow from 6400 veh/h to 3200 veh/h to find the max throughput. Also, it could be seen that in which flow the queue disappeared. I ran the CORSIM with 6 random seed numbers for each input flow and got the mean throughput of these data. Then, I calculated the standard deviation for throughputs and by dividing the standard deviation of throughputs by mean throughput, it can be seen that this amount for all input flows is less than 7%, so the results are acceptable. The mean throughput and queue condition for different input flows are shown in the Table(20).

	Location(Camcorder1)	Location(Camcorder3)	
Input (vehicle/hour)	**Number of Throughput Vehicle/hour/lane**	**Number of Throughput Vehicle/hour/lane**	**Queue Condition**
6400	1569	775	Queue
6000	1610	795	Queue
5600	1618	801	Queue
5200	1665	819	Queue
4800	1615	799	Queue
4400	1606	805	Queue
4000	1579	797	Queue
3800	1598	811	Queue
3700	1642	840	Queue
3600	1784	899	No Queue
3500	1750	874	No Queue
3400	1700	849	No Queue
3200	1599	799	No Queue

Table(20). Mean Throughput and Queue Condition for Different Input Flows

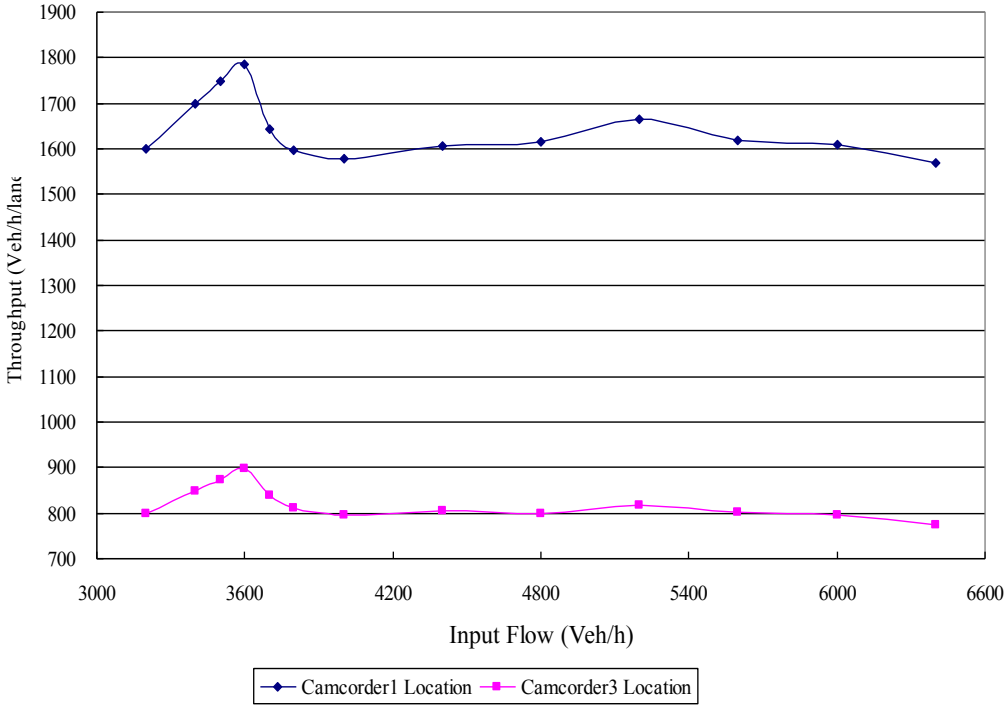
It can be seen in the Table (20) that the max throughput in both locations (camcorder1 & 3 locations) takes place at the same input flow (3600 veh/hour). Also, this flow is exactly when the queue disappears.

The standard deviation of throughputs divided by mean throughput for different input flows is shown in the Table (21). All of the numbers are below 7 % and it shows that our results are good.

	Location(Camcorder1)	**Location(Camcorder3)**
Input (vehicle/hour)	**Standard Deviation/Mean %**	**Standard Deviation/Mean %**
6400	1.3	1.7
6000	4.8	4.7
5600	3.2	3.3
5200	6.4	6.5
4800	2.3	2.8
4400	2.4	2.6
4000	1.4	1.6
3800	2.0	2.6
3700	3.0	3.5
3600	2.0	0.4
3500	0.1	0.1
3400	0.1	0.1
3200	0.1	0.1

Table(21). Standard Deviation/Mean of Throughputs for Different Input Flows

The throughputs in both locations are drawn versus input flow in Figure(3).



Figure(3). Throughput in Both Locations versus Input Flow

6. Estimating the Max Throughput for Different Truck Percentages

We changed the truck percentage and with 3 random seed numbers we calculated the max throughput. The results can be seen in the Table(22)_(27).

5% Truck Percentage		
	Location(Camcorder1)	Location(Camcorder3)
Input (vehicle/hour)	Number of Throughput (Vehicle/hour/lane)	Number of Throughput (Vehicle/hour/lane)
6000	1623	802
5600	1734	855
5200	1754	870
4800	1726	859
4400	1731	864
4000	1631	831
3800	1852	938
3700	1790	905
3600	1800	899
3400	1700	849

Table(22). Throughputs in Camcorder1 & 3 Locations versus Different Input Flows for 5% Truck Percentage

10% Truck Percentage		
	Location(Camcorder1)	Location(Camcorder3)
Input (vehicle/hour)	Number of Throughput (Vehicle/hour/lane)	Number of Throughput (Vehicle/hour/lane)
6000	1602	797
5600	1601	789
5200	1600	788
4800	1590	791
4400	1669	838
4000	1590	801
3800	1577	801
3700	1630	834
3600	1795	900
3500	1750	874
3400	1698	849
3200	1598	800

Table(23). Throughputs in Camcorder1 & 3 Locations versus Different Input Flows for 10% Truck Percentage

20% Truck Percentage		
	Location(Camcorder1)	Location(Camcorder3)
Input (vehicle/hour)	Number of Throughput (Vehicle/hour/lane)	Number of Throughput (Vehicle/hour/lane)
6000	1496	741
5600	1475	729
5200	1487	733
4800	1509	745
4400	1499	745
4000	1487	745
3800	1480	745
3700	1489	750
3600	1495	755
3500	1501	765
3400	1627	819
3300	1650	824
3200	1599	799

Table(24). Throughputs in Camcorder1 & 3 Locations versus Different Input Flows for 20% Truck Percentage

30% Truck Percentage		
	Location(Camcorder1)	Location(Camcorder3)
Input (vehicle/hour)	Number of Throughput (Vehicle/hour/lane)	Number of Throughput (Vehicle/hour/lane)
4400	1395	691
4000	1389	694
3600	1385	698
3400	1400	710
3300	1413	716
3200	1515	776
3100	1549	775
3000	1498	750

Table(25). Throughputs in Camcorder1 & 3 Locations versus Different Input Flows for 30% Truck Percentage

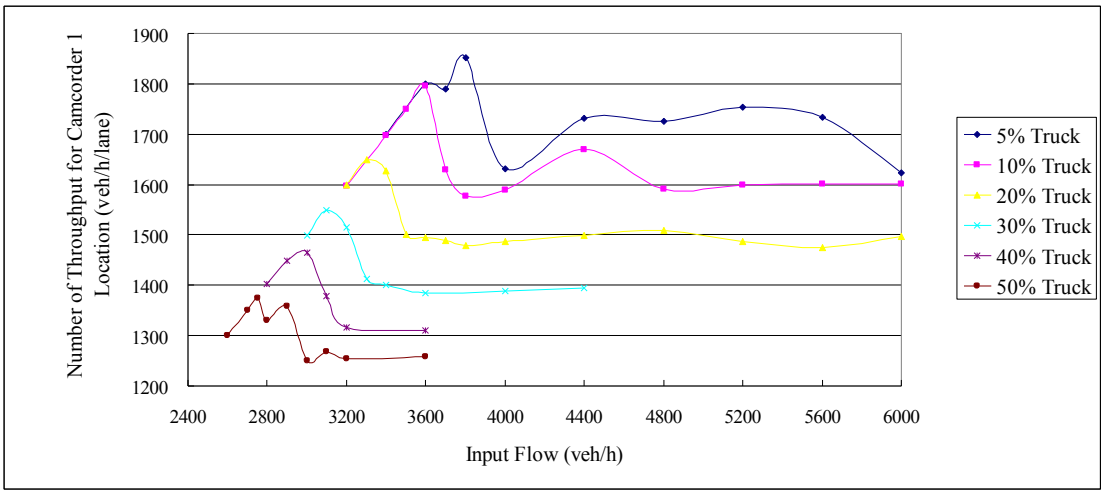
40% Truck Percentage		
	Location(Camcorder1)	Location(Camcorder3)
Input (vehicle/hour)	Number of Throughput (Vehicle/hour/lane)	Number of Throughput (Vehicle/hour/lane)
3600	1310	659
3200	1316	668
3100	1378	706
3000	1465	743
2900	1448	724
2800	1403	699

Table(26). Throughputs in Camcorder1 & 3 Locations versus Different Input Flows for 40% Truck Percentage

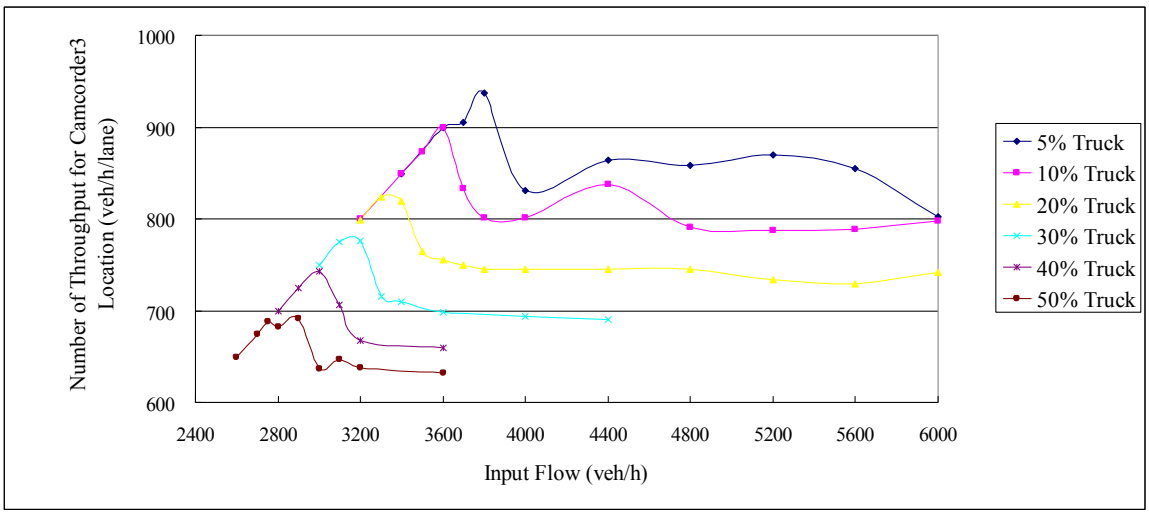
50% Truck Percentage		
	Location(Camcorder1)	Location(Camcorder3)
Input (vehicle/hour)	Number of Throughput (Vehicle/hour/lane)	Number of Throughput (Vehicle/hour/lane)
3600	1259	632
3200	1254	637
3100	1268	646
3000	1251	637
2900	1358	692
2800	1331	682
2750	1374	688
2700	1351	674
2600	1300	649

Table(27). Throughputs in Camcorder1 & 3 Locations versus Different Input Flows for 50% Truck Percentage

The graph of the throughputs in camcorder1 location is shown in Figure (4) and the graph for camcorder3 location is shown in Figure (5).



Figure(4). Throughput in Camcorder1 Location versus Input Flow for Different Truck Percentages

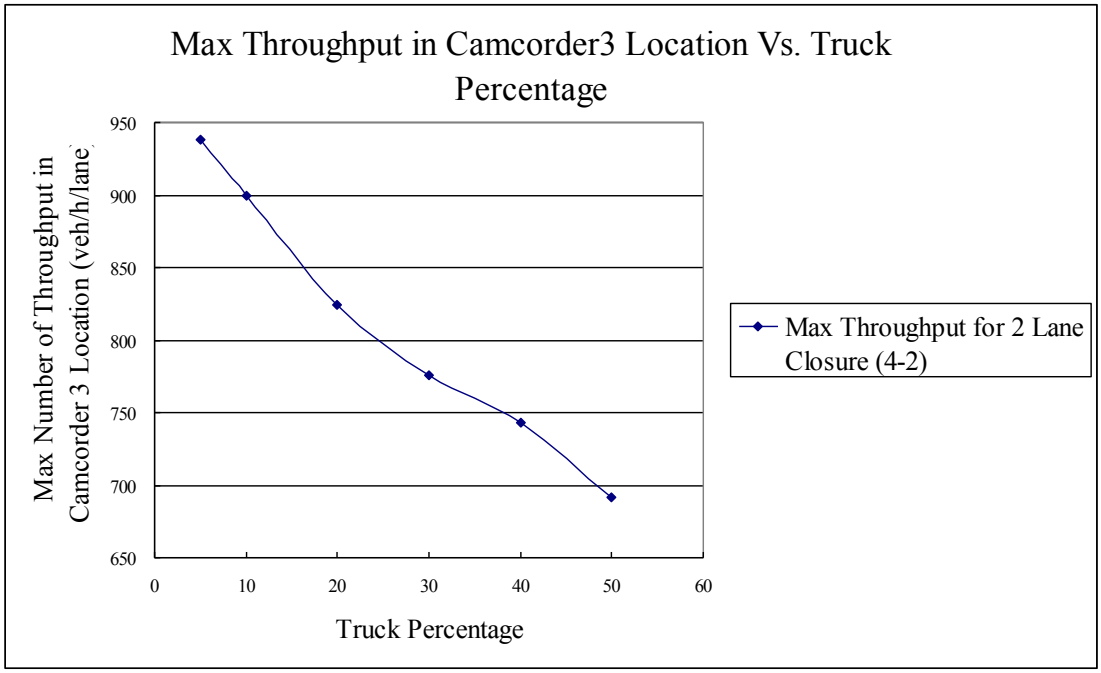


Figure(5). Throughput in Camcorder3 Location versus Input Flow for Different Truck Percentages

Max throughput in Camcorder 3 Location for different truck percentages are shown in Table(28) and the graph is shown in Figure(6).

Percentage of Trucks	Max Number of Throughput in Camcorder 3 location (Vehicle/hour/lane)
5% Truck	938
10% Truck	900
20% Truck	824
30% Truck	776
40% Truck	743
50% Truck	692

Table (28). Max Throughput in Camcorder3 Location for Different Truck Percentages



Figure(6). Max Throughput in Camcorder3 Location for Different Truck Percentages (for 2 Lane Closure)

7. Estimating the Max Throughput for Different Truck Percentages for 1 Lane Closure (4-3 lane)

We changed the geometry of work zone to have only one lane closure and changed the truck percentage and with 3 random seed numbers we calculated the max throughput. The results can be seen in the Table(29)_(34).

5% Truck Percentage		
	Location(Camcorder1)	Location(Camcorder3)
Input (vehicle/hour)	Number of Throughput (Vehicle/hour/lane)	Number of Throughput (Vehicle/hour/lane)
6000	1269	923
5600	1269	917
5200	1266	914
4800	1273	928
4400	1280	943
4200	1283	950
4100	1334	996
4080	1345	1011
4000	1333	998
3800	1267	949
3600	1198	899

Table(29). Throughputs in Camcorder1 & 3 Locations versus Different Input Flows for 5% Truck Percentage

10% Truck Percentage		
	Location(Camcorder1)	Location(Camcorder3)
Input (vehicle/hour)	Number of Throughput (Vehicle/hour/lane)	Number of Throughput (Vehicle/hour/lane)
6000	1242	897
5600	1243	903
5200	1246	905
4800	1242	906
4400	1246	916
4200	1249	924
4100	1255	929
4000	1333	999
3800	1267	949
3600	1200	898
3200	1066	800

Table(30). Throughputs in Camcorder1 & 3 Locations versus Different Input Flows for 10% Truck Percentage

20% Truck Percentage		
	Location(Camcorder1)	Location(Camcorder3)
Input (vehicle/hour)	Number of Throughput (Vehicle/hour/lane)	Number of Throughput (Vehicle/hour/lane)
6000	1206	882
5600	1220	895
5200	1205	879
4800	1216	891
4400	1209	886
4000	1223	907
3900	1252	944
3800	1264	950
3700	1231	924
3600	1199	899
3200	1067	800

Table(31). Throughputs in Camcorder1 & 3 Locations versus Different Input Flows for 20% Truck Percentage

30% Truck Percentage		
	Location(Camcorder1)	Location(Camcorder3)
Input (vehicle/hour)	Number of Throughput (Vehicle/hour/lane)	Number of Throughput (Vehicle/hour/lane)
4400	1186	869
4000	1186	879
3900	1189	883
3800	1200	899
3700	1215	912
3600	1199	900
3200	1068	799

Table(32). Throughputs in Camcorder1 & 3 Locations versus Different Input Flows for 30% Truck Percentage

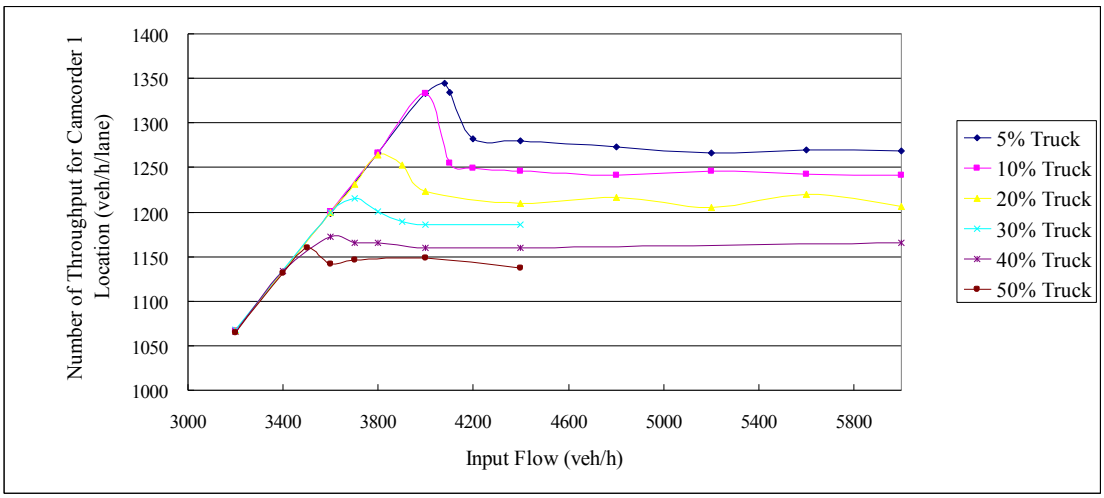
40% Truck Percentage		
	Location(Camcorder1)	Location(Camcorder3)
Input (vehicle/hour)	Number of Throughput (Vehicle/hour/lane)	Number of Throughput (Vehicle/hour/lane)
6000	1165	861
4400	1159	853
4000	1159	860
3800	1166	867
3700	1165	871
3600	1173	887
3400	1134	849
3200	1065	799

Table(33). Throughputs in Camcorder1 & 3 Locations versus Different Input Flows for 40% Truck Percentage

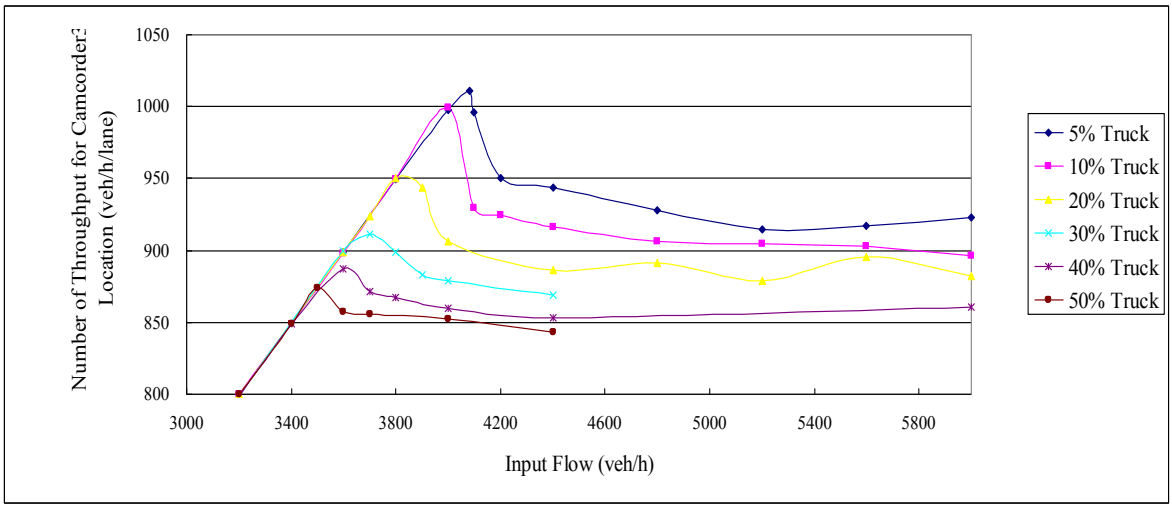
50% Truck Percentage		
	Location(Camcorder1)	Location(Camcorder3)
Input (vehicle/hour)	Number of Throughput (Vehicle/hour/lane)	Number of Throughput (Vehicle/hour/lane)
4400	1138	843
4000	1148	852
3700	1146	856
3600	1142	857
3500	1160	874
3400	1131	849
3200	1064	800

Table(34). Throughputs in Camcorder1 & 3 Locations versus Different Input Flows for 50% Truck Percentage

The graph of the throughputs in camcorder1 location is shown in Figure (7) and the graph for camcorder3 location is shown in Figure (8).



Figure(7). Throughput in Camcorder1 Location versus Input Flow for Different Truck Percentages (for 1 Lane Closure)

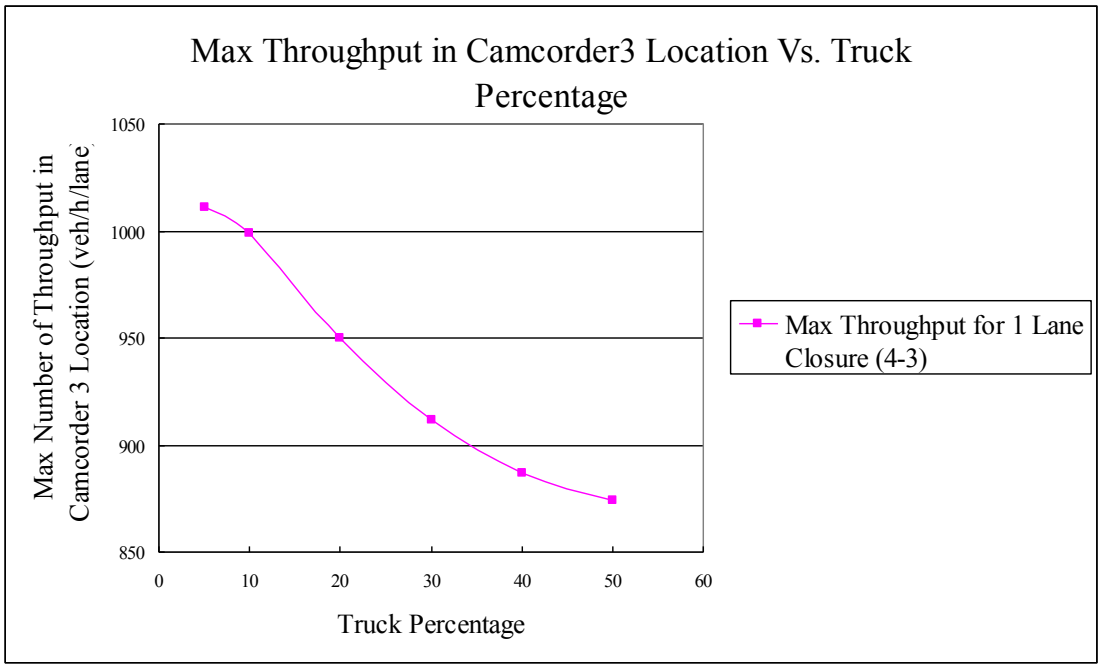


Figure(8). Throughput in Camcorder3 Location versus Input Flow for Different Truck Percentages (for 1 Lane Closure)

Max throughput in Camcorder 3 Location for different truck percentages are shown in Table(35) and the graph is shown in Figure(9).

Percentage of Trucks	Max Number of Throughput in Camcorder 3 location (Vehicle/hour/lane)
5% Truck	1011
10% Truck	999
20% Truck	950
30% Truck	912
40% Truck	887
50% Truck	874

Table(35). Max Throughput in Camcorder3 Location for Different Truck Percentages (for 1Lane Closure)

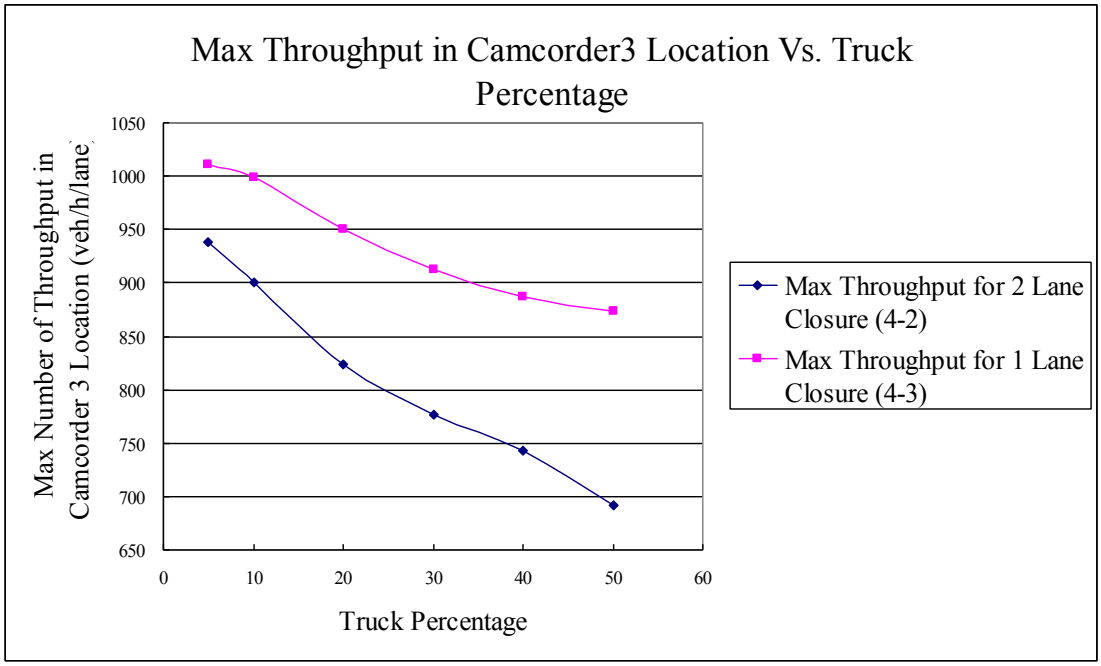


Figure(9). Max Throughput in Camcorder3 Location for Different Truck Percentages (for 1 Lane Closure)

The comparison of max throughput in camcorder3 location for 1- lane closure and 2- lane closure for different truck percentages can be seen in Table(36) and Figure(10).

Percentage of Trucks	Max Number of Throughput in Camcorder 3 location (Vehicle/hour/lane)	
	2 lane closure(4-2)	1 lane closure(4-3)
5% Truck	938	1011
10% Truck	900	999
20% Truck	824	950
30% Truck	776	912
40% Truck	743	887
50% Truck	692	874

Table(36). Comparison of Max Throughput in Camcorder3 Location for Different Truck Percentages for 1Lane & 2Lane Closure



Figure(10). Comparison of Max Throughput in Camcorder3 Location for Different Truck Percentages for 1 Lane & 2 Lane Closure

8. Conclusion

It can be seen in the results that max throughput in both locations takes place with the same input flow and also the max throughput happens exactly before queue starts. As it was obvious，by increasing the truck percentage the max throughput decreases.

In addition, the max throughput in camcorder3 location is higher when only one lane is closed in comparison with 2 lane closure throughput.

Decreasing in camcorder1 location throughput for 1 lane closure in comparison with 2 lane closure is because of limitation in camcorder3 location throughput (for example for 5% truck percentage the max throughput in camcorder3 location is 1011 veh/h/lane and there are

4lanes so the total numbers of throughput is 4044. These vehicles should pass through 3 lanes ,therefore the max throughput in camcorder1 location is 1345).

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