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Mix Use Traffic and Added Impedance Affecting Traffic Flow Variables

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Abstract

Urbanization coupled with industrial and commercial boom has brought many challenges giving rise to heterogeneous traffic flow. Heavy vehicles result in congestion and speed drop with an ultimate increase in travel time and fuel wastage. The characterization of congestion is of vital importance to understand and manage heterogeneous traffic flow operations. To gauge the effect of bottlenecks compared with heavy vehicles on the speed and travel time of vehicles, a study has been undertaken. The different traffic scenarios were considered to answer the research question. Results showed that bottlenecks and heavy vehicles affect the average speed and travel time of the vehicles

Keywords - *Heterogeneous Traffic, Traffic Flow Variables, Speed Reduction, Heavy Vehicles, Bottlenecks*

I. INTRODUCTION

The industrial revolution has rendered many services to human society as a by-product of traffic congestion in the global urbanization era. Usually, traffic congestion is one of the fundamental issues in traffic flow studies. The repaid surge in population with urbanization trends in the last few decades has resulted in traffic congestion with reference to our country in particular and other developing countries in general. The presence of heavy vehicles (all types of trucks) coupled with bottlenecks has pronounced effects on average speed and travel time. The driver's behavior of the heavy vehicles and passenger cars are also different from one another [1,2,3], therefore, casting measured effects on homogeneous traffic flow and fuel economy. Although bottlenecks are not frequently encountered for the given section of traffic along with heavy vehicles proportion, yet their cumulative impact contributes significantly to urban traffic congestion [4].

Congestion due to heavy vehicles and bottleneck is the result of physical character (dimension of the vehicle) and geographic location; heavy vehicles and bottlenecks have physiological and psychological effects on the surrounding. These impacts, studied in [5-8,11], results/trials, have depicted that these characteristics become more obvious under heavy traffic conditions. In the past, no worthwhile attention has been paid to the effects of a heavy vehicle on the operational characterization of traffic. It has also been validated through previous studies that light vehicles' drivers avoid following/remain in the vicinity of heavy vehicles. Therefore, larger gaps are subsequently created between heavy vehicles. The driver's behavior is also enraged as they try to change the lane to attain optimal speed to avoid congestion. The overall aggressive [6, 9,10] behavior of all drivers, therefore, takes the toll of many lives as the potential risk of road traffic accidents increases manifold, and no road/traffic safety measures are enforced.

In this study, a thorough examination of operational characteristics of traffic in the presence of bottlenecks is presented in terms of speed and travel time. The effect of heavy vehicles and the presence of bottleneck on travel time and speed of the light vehicle is calculated on the newly constructed road Mandra – Chakwal, a dual carriageway in Punjab, Pakistan.

This paper is further organized as In Section-2, the detailed methodology of the study is presented. The results of the study are presented in Section-2, and conclusions are given in Section-4.

II. METHODOLOGY

A preliminary survey was done to identify the effects of heavy vehicles and bottlenecks on the speed and travel time of light vehicles. Mandra-Chakwal Dual Carriageway was identified where frequent lane changing the behavior of drivers was observed due to the presence of heavy vehicles and frequency of U-turns/bottlenecks. The relatively high density of mixed traffic is also there. The traffic shock wave is a routine phenomenon due to the acceleration and deceleration of light vehicles.

Two videos camera were installed on the road section of 200 m to record road traffic data, which were used to calculate the speed and travel time of heavy and light vehicles. Different traffic flow conditions were analyzed such that when there were only light vehicles on the road, heavy vehicles in the presence of light vehicles, and impact of U-turn in the presence of both.

A. Traffic Condition 1:

Firstly, traffic condition was considered for the light vehicles when there were no heavy vehicles and bottleneck on the road (free flow of traffic). The total no of vehicles analyzed is 10 for the 200 m long

section of the road. The traffic data is given in Table 1.

Table 1: Average Travel Time and Speed of Vehicles for 200 m Road section with no bottlenecks.

Sr No	Description	Time (In) s	Time (Out) s	Travel Time s	Distance m	Speed m/s	Speed km/hr
1	Motor bike	7.04	18.02	10.98	200	18.21494	65.57
2	Motorbike	7.08	18.1	11.02		18.14882	65.33575318
3	HiAce	8.86	20.2	11.34		17.63668	63.49
4	Motor bike	8.88	20.4	11.52		17.36111	62.50
5	HiAce	9.02	21.1	12.08		16.55629	59.60
6	Car	9.04	22	12.96		15.4321	55.56
7	Car	9.1	23	13.9		14.38849	51.80
8	Car	9.14	24	14.86		13.45895	48.45
9	Car	10	25.6	15.6		12.82051	46.15
10	Sizuki Pickup	10.24	29.96	19.72		10.14199	36.51
					Avrage Travel Time of the Section		13.40
					Average Free Flow Speed		55.50

The average speed of the vehicles is 55.50 km/hr, whereas the average travel time is 13.40 sec. The traffic flow is smooth, and less lane changing behavior was observed.

B. Traffic Condition 2

In the second phase, the traffic condition of light vehicles in the presence of a 1 x mini truck was considered. The traffic data for the second traffic condition is given in Table 2.

Table 2: Average Travel Time and Speed of Vehicles for 200 m Road section with 1 bottleneck.

Sr No	Description	Time (In) s	Time (Out) s	Travel Time s	Bottleneck	Distance m	Speed m/s	Speed km/hr
1	Car	32.2	47.74	15.54	1	200	12.87001	46.33
2	Car	33.02	47.66	14.64			13.6612	49.18032787
3	SUV	33.18	43.7	10.52			19.01141	68.44
4	Car	33.22	43.72	10.5			19.04762	68.57
5	Mini truck	33.4	50	16.6			12.04819	43.37
6	Car	33.56	49.8	16.24			12.31527	44.33
7	Motor bike	33.62	50.4	16.78			11.91895	42.91
8	Car	33.62	49.9	16.28			12.28501	44.23
9	Motor bike	33.66	50.4	16.74			11.94743	43.01
10	HiAce	33.7	50.5	16.8			11.90476	42.86
						Avrage Travel Time of the Section		15.06
						Average Free Flow Speed		49.32

For the second traffic condition, the average speed of the section is 49.32 km/hr, whereas the average travel time recorded is 15.06 sec with heavy vehicles percentage of 10 %.

C. Traffic condition 3

Traffic condition was considered for the heavy and light vehicles in the presence of U-turn (bottleneck) at a distance of 160 m. The traffic data of the third traffic condition is given in Table 3.

Table 3: Average Travel Time and Speed of Vehicles for 200 m Road section with 1 bottleneck and Heavy vehicles.

Sr No	Description	Time (In) s	Time (Out) s	Travel Time s	Bottleneck	Distance m	Speed m/s	Speed km/hr
1	Heavy truck	43	67.2	24.2	1	200	8.264463	29.75
2	Motor bike	43.1	59.8	16.7			11.97605	43.11377246
3	Car	43.18	62	18.82			10.62699	38.26
4	Car	43.22	62.2	18.98			10.53741	37.93
5	Heavy truck	43.26	69.8	26.54			7.535795	27.13
6	Car	43.34	67.6	24.26			8.244023	29.68
7	SUV	43.38	67.8	24.42			8.190008	29.48
8	Motor bike	43.42	68.2	24.78			8.071025	29.06
9	HiAce	43.46	68	24.54			8.149959	29.34
10	Mini truck	45.06	68.02	22.96			8.710801	31.36
						Avrage Travel Time of the Section		22.62
						Average Free Flow Speed		32.51

The average section speed is 32.51 km/hr. And the average travel time is 22.62 sec with a heavy vehicle percentage of 20 %.

III. RESULTS

The impact of heavy vehicles in the presence of U-turn on the speed and travel time of light vehicles is considered/studied. Heavy vehicles and the location of U-turns affects the behavior of drives and is characterized by the average speed and average travel time. In the first traffic condition, there were only light vehicles on the road section (free-flow traffic). The results show that there were fewer changes in the velocities, and the density of the light vehicles increased, being inversely proportional. Figure 1 shows the travel time and speed relationship.

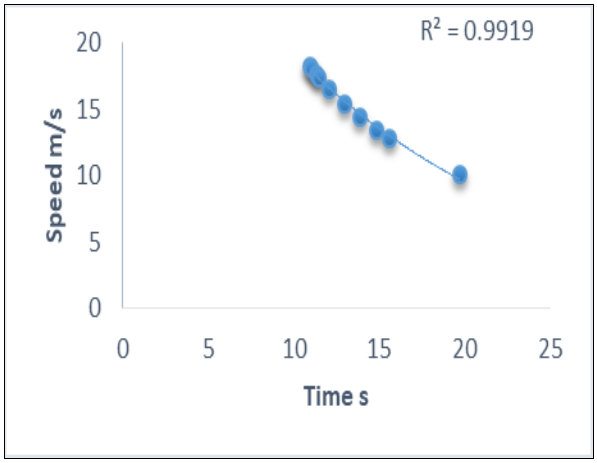

Figure 1: Speed and Travel Time Relation for 200 m Road section with no heavy traffic and bottlenecks.

Results show that when there are no heavy vehicles on the road, drivers adjust their speed freely without changing their respective lanes. Most of the vehicles travel at the desired speed. Out of ten

vehicles, speeds of eight vehicles range between 45 to 66 km/hr.

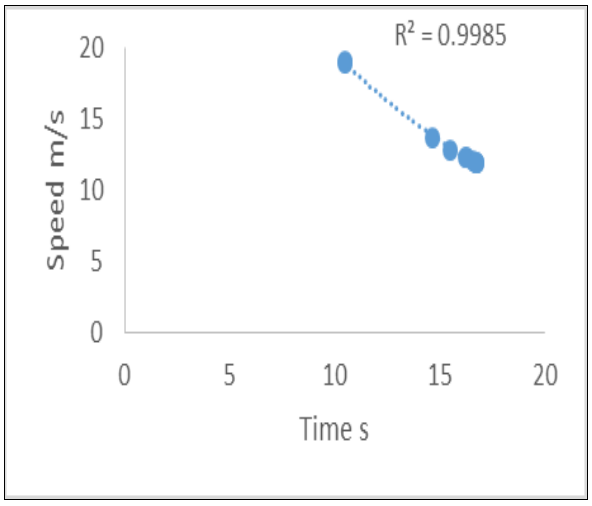

Figure 2: Speed and Travel Time Relation for 200 m Road section with heavy traffic and a bottleneck.

When a heavy vehicle was considered in the second traffic condition, the average speed of the section decreased, and the average travel time increased. The average travel time increased by 1.6 sec and the average speed of the section decreased by 6.18 km/hr, which is the result of a single heavy vehicle.

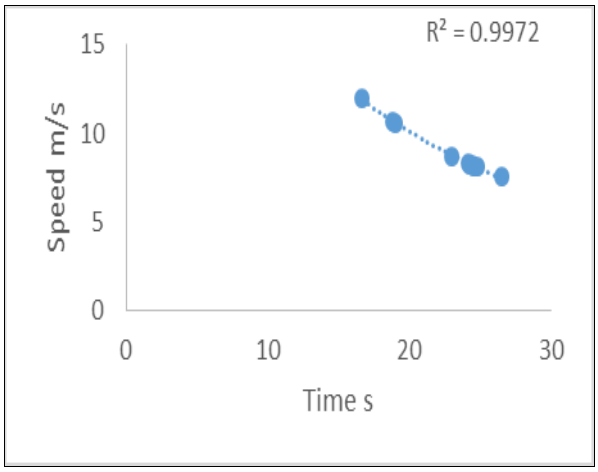

Figure 3: Speed and Travel Time Relation for 200 m Road section with heavy traffic and a bottleneck.

The third traffic condition is presented in Figure 3. With the presence of bottleneck and enhanced densities of heavy vehicles, there are higher speed drops, which shows the impact of heavy vehicles and U turn-on speed of light vehicles. The third traffic condition is compared with the first traffic condition, and there is an increase of 9.22 sec in the average travel time of the section, which results in the average speed drop, which is 22.62 km/hr.

The travel time losses and speed drop experimentally observed for three different conditions show the impact of heavy vehicles and U-turn presence on light vehicles. It is essential to comprehend that such traffic flow causes traffic congestion on an urban road. In this study, we have proved that heavy vehicles physically and psychologically affect the drivers of light vehicles, which is the root cause of drivers' aggression, and, in turn, results in a traffic stop and go behavior and lane-changing behavior, which decrease road safety and speed and increase travel time.

IV. CONCLUSION

An in-depth analysis to evaluate the average speed and travel time of three different conditions was made and compared accordingly. Vehicular traffic is more influenced by heavy vehicles and bottlenecks as compared to light vehicles. The presence of heavy vehicles and bottleneck results in a higher speed drop increase in travel time and frequent lane-changing behavior, which causes traffic congestions as well as contributes to economical and societal losses.

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