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Factors Impacting Serviceability of Bypass Road

Anees Ahmad[1], Jamal Ahmed Khan[2], Azeem Ullah Shah[3]
[1]*Research Scholar,* [2]*Lecturer,* [3]*Research Scholar, Department of Civil Engineering, UET Taxila, Pakistan*

Abstract: ***Urban traffic congestion is one of the major problems of the developing countries. Growing volumes of through traffic are often attributed to traffic flow challenges. Bypass roads are constructed to reduce congestion in the city center. Bypass diverts through traffic away from town centers leaving local streets to local traffic. Often these bypasses are built to accommodate increasing volumes of traffic particularly truck traffic. The aim of this research is how to improve travel time on bypass roads and to study various traffic congestion management approaches in big cities. Traffic volume, travel time, vehicle specifications and geometric parameters were determined in the field as input for the microsimulation model. Different facilities were incorporated on bypass road to improve travel time. Calibration and validation of the model were done, and results of traffic volume and travel time were compared with actual field data. The results obtained shows that in most of the cases congestion was found near the intersections. The options of a flyover, bus bays, pedestrian overhead bridge and slip lines were assumed in the analysis; in result highest travel time decrease on bypass road due to provision of slip lines.***
Keywords: Congestion, Bypass Road, Travel Time, PTV Vissim Software, Micro-Simulation

I. INTRODUCTION

Bypass roads are constructed to shift heavy traffic from the city centre to reduce traffic congestion. It is very effective in reducing traffic congestion as heavy loaded vehicles diverted to an alternate route reducing burden in the main city center route as a result travel time on both routes decreased. Besides bypass roads, there are many alternatives which are used by other countries to reduce traffic congestion. Stockholm introduces congestion pricing in 30 km^2 area. Traffic across the cordon dropped immediately, leading to dramatic congestion reduction all over the city [1]. Heavy engineering actions like ring road development, building new roads etc. Push and Pull strategies including promoting public transportation, biking, and walking as well as reducing the use of cars. For managing traffic congestion, a combination of push and pull techniques as well as heavy engineering solutions is recommended [2]. In order to boost revenue, reduce congestion, and improve the environment, Gothenburg implemented a time-of-day dependent cordon-based congestion pricing scheme which results in reducing traffic congestion and environmental pollution [3]. Avissawella and Mawanella constructed new bypass road which attracts residential land uses and gradually the bypass road was also able to attract commercial land use. The potential for attracting vehicle flow is comparable for existing and bypass roads [4]. Free public bus transport was introduced in the Hasselt, the urban busses are free for everybody (not only inhabitants of Hasselt) which increased the use of public transport and decrease the use of private vehicles [5]. In order to enter an 8 km2 region of the city core, Milan established a pricing system. Ecopass, a pass to enhance the quality of the urban environment, is the name given to the program. The following are excluded from fees: motorcycles, public transportation, handicapped vehicles, army and police vehicles, vehicles used for public services, and ambulances. More than the environmental advantages, the biggest social advantages seem to be associated with less traffic and a drop in accidents. [6]. There is a tendency for equilibrium to be maintained by traffic congestion. There comes a point where traffic congestion makes it difficult to make further journeys during peak hours. Increasing road capacity enables more vehicle movement, which causes renewed congestion with increased traffic levels [7]. Bypassing areas with heavy traffic, expanding the capacity of streets and roads, and enhancing driving conditions (by eliminating gridlock, raising speeds to the lowest possible levels for pollution, and promoting smoother driving), it is possible to reduce fuel consumption and the release of gases that contribute to the greenhouse effect [8]. Bypass roads alters land use, travel behavior by diverting traffic from city center to increase the flow, reduce travel times, improve accessibility & road safety, reduce noise and overall improve the environment in metropolitan areas [9]. Oslo has improved public transportation to reduce congestion by segregating it from other traffic, giving it priority at crossings, maximizing stop distances, reducing the amount of parking spaces, relocating parking spaces, implementing a digital ticketing system, and raising parking prices by 50% [10]. PTV Vissim, one of the most often used microscopic traffic simulators, was primarily created for use in European traffic situations but is now increasingly being used in developing nations. Simulation has been recognized as one of the best tools for modeling of traffic flow under homogeneous as well as heterogeneous conditions. In comparison to analytical data, the outcomes from a simulation model that has been validated would be more accurate [11].

II. PROBLEM STATEMENT

In recent years, due to rapid increase in population and urbanization traffic congestion become a common problem in all big cities. Bypass roads are constructed to mitigate traffic congestion, decrease travel time, reduce accidents rate, increase traffic safety and diminish the appearance of bottlenecks. For a certain period of time the bypass roads perform its function well but after sometime due to change in land use pattern and increase in volume of traffic bypass fails to perform its function effectively. In Pakistan, bypass roads are not properly designed, constructed and maintained to ensure its function in future.

III. OBJECTIVES OF RESEARCH STUDY

The overall aim of the study is to reduce congestion, improve travel time and the functionality of the bypass road. The following is the list of objectives to achieve the specific aim.

1) To study various traffic congestion management approaches in big cities.
2) To investigate various factors impacting the serviceability of bypass roads.
3) To model the identified factors to mitigate current congestion issues on bypass roads.

IV. METHODOLOGY

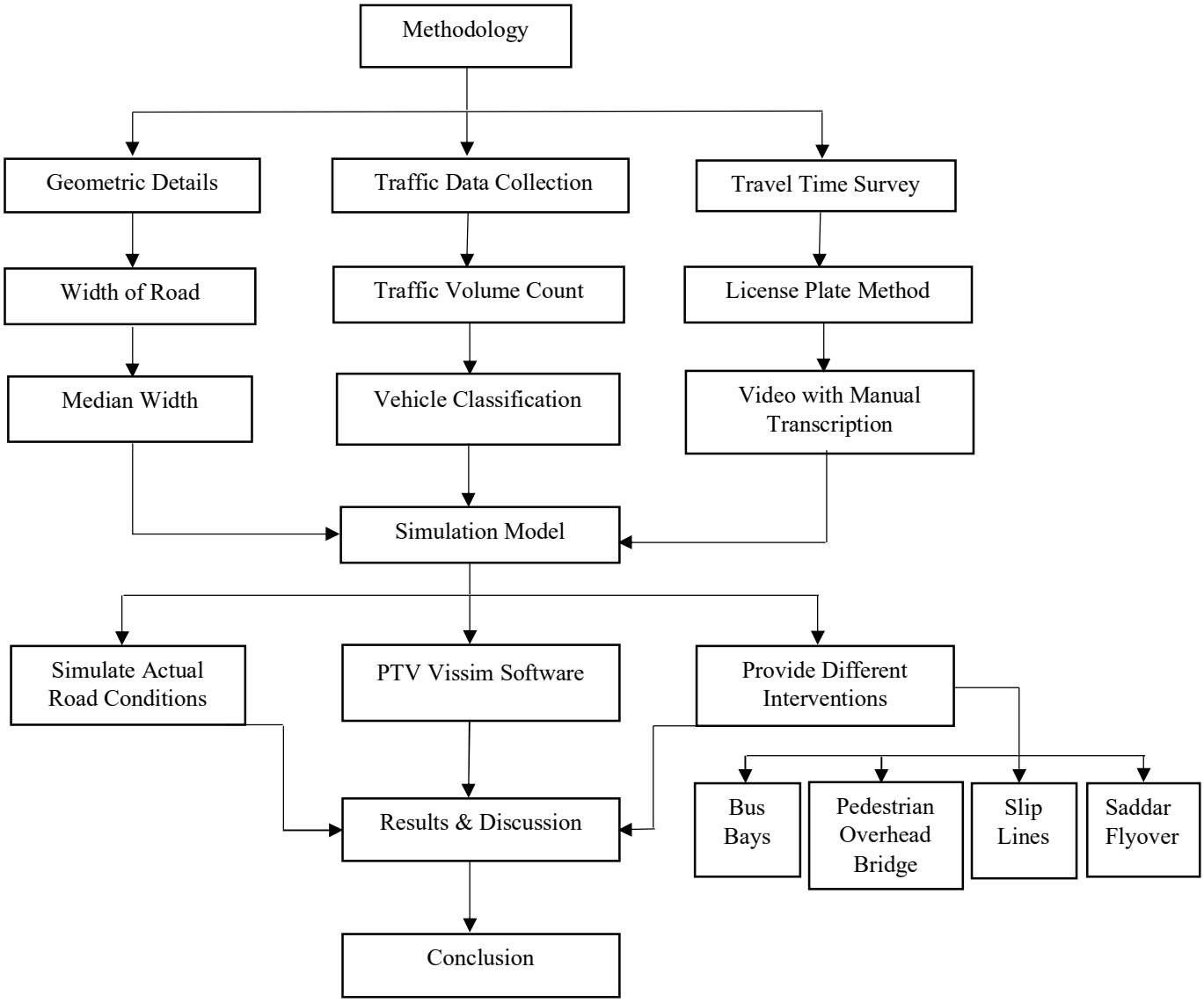

Fig 1: Scope of research study

A. Site Selection

The port city of Karachi and the border crossing at Torkham are connected by Pakistan's longest roadway, National Highway 5. It has a 1756-kilometre overall length. Nowshera district is situated in Khyber Pakhtunkhwa province between Peshawar and Attock, connecting KPK to Punjab. Nowshera bypass road is situated on N5 route. It has a central business district and a cantonment area therefore; heavy loaded vehicles are not allowed to pass through. An alternate route (bypass road) is used by these heavy loaded vehicles. Total length of Nowshera bypass road is 4.7km. It's a four-lane road having two lanes in each direction. Fig 2 shows Nowshera bypass road map.

Fig 2: Nowshera Bypass road map

TABLE 1
INVENTORY OF FACILITIES AND ACCESSES ALONG NOWSHERA BYPASS ROAD

S.no	Facilities and Accesses	Remarks
1	Number of lanes in each direction	2
2	Shoulders provided	No
3	Walkways provided	No
4	Availability of services lanes/roads	No
5	Number of bus stops provided including illegal ones	0
6	Number of direct accesses to abutting properties/roads	10
7	Number of pedestrian crossing facility	0

TABLE 1 shows that shoulders, walkways, service lanes and pedestrian crossing facility were not provided along the bypass road.

B. Geometric Survey

Nowshera bypass road has length of 4.7km. It has 4 lanes with two lanes in each direction. The opposite lanes of bypass road are separated by a median. The lane width was found at different locations to make accuracy in plotting road in PTV Vissim. Table 2 shows width of Nowshera bypass road at different segments.

TABLE 2
ROAD WIDTH PROFILE

Initial point (meter)	Final point (meter)	Length of segment (meter)	Width (meter)	Two lane width (meter)	Single lane width (meter)
0	2168	2168	14.37	7.185	3.5925
2168	2230	62	12.887	6.4435	3.22175
2230	2491	261	17.52	8.76	4.38
2491	4176	1685	15.3	7.65	3.825
4176	4722.4	546.4	17.4	8.7	4.35

C. Traffic Data Collection

Vehicle counts were carried out for seven days of a week from Monday to Sunday. Cameras were fixed at both ends of bypass road at peak hours and non-peak hours of the day. Manual traffic volume data collection through video camera method was chosen and classified vehicles into six categories as follows:

1) Trucks
2) Tractors
3) Wagon
4) Buses
5) Car/Jeep
6) Motorcycle

Vehicles using full bypass road and those dissipating in bypass road were counted separately.

D. Travel Time Calculation

Actual travel time of vehicles using full bypass road was calculated. Video with manual transcription method was used for travel time survey. Video cameras were fixed at both ends of the bypass road which recorded vehicle entry time and exit time. It also recorded number of vehicles using bypass road. Video was recorded for specific period of time and then number of vehicles and travel time was recorded manually. Vehicles using full bypass road included: Trucks, Tractors, Car, Wagon and Motorcycle. Traffic volume data and travel time data were collected for 7 days at three time periods.

1) Morning Peak period
2) Off-Peak period
3) Evening Peak period

E. PTV Vissim Software

PTV Vissim is a microscopic multi-modal traffic flow simulation software package. In Vissim, 4.7 km road was made which simulates actual road condition of Nowshera bypass. Each intersection was created along with conflict points, priority rules, speed breakers and stopping points. Different categories of vehicles i.e car, truck, tractor, wagon and motorcycle were added to the simulation along with speed profile. The results obtained from simulation were compared with the actual field data along with the improvements provided i.e. bus bays, Slip lines, Pedestrian overhead bridge and Flyover. Fig 3 shows Nowshera bypass road drawn in PTV Vissim. Fig 4 shows conflict points and priority rules at intersections of bypass road. Fig 5 shows traffic simulation run in PTV Vissim software.

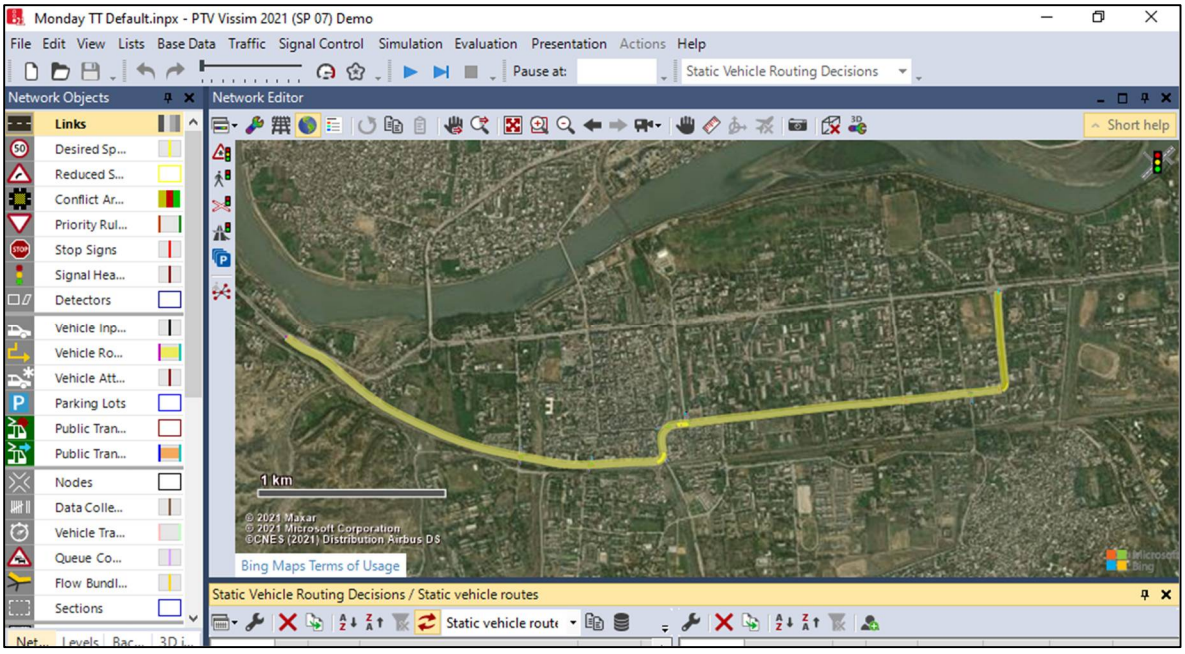

Fig 3: Bypass road drawn in PTV Vissim

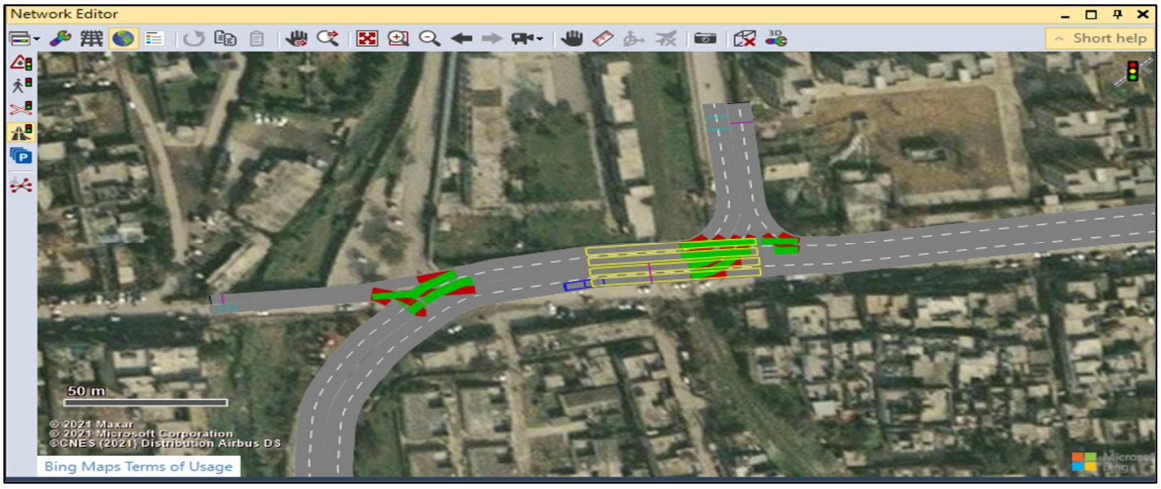

Fig 4: Conflict points at intersection

Fig 5: Traffic simulation

V. RESULTS & DISCUSSION

Fig 7 shows minimum and maximum values of traffic composition at west bound. Fig 8 shows minimum and maximum values of traffic composition at east bound. Traffic composition varies between these values.

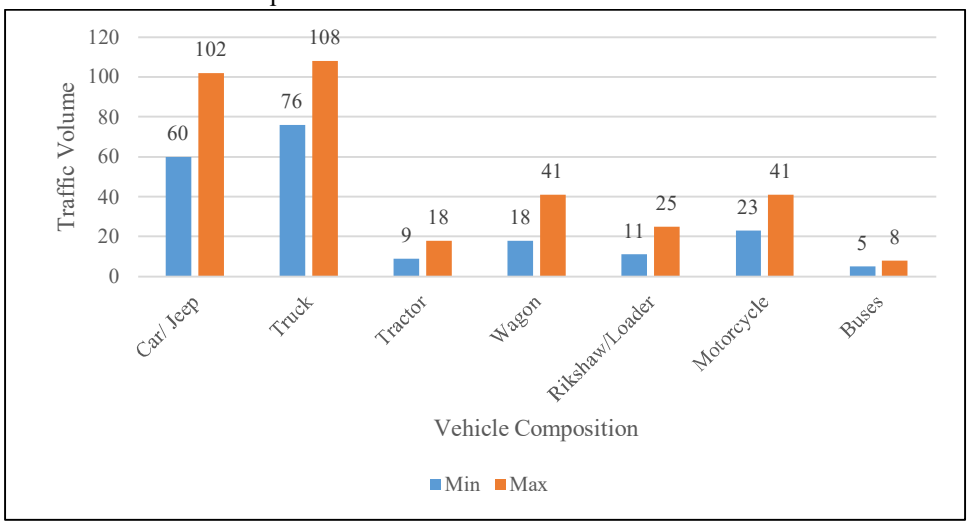

Fig 7: Traffic composition in west bound direction

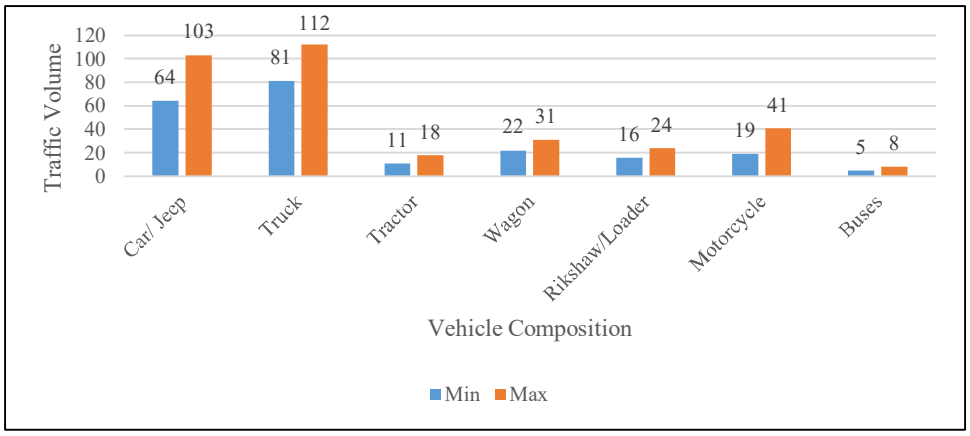

Fig 8: Traffic composition in east bound direction

Fig 9 and 10 shows the comparison of actual average travel time and simulated average travel time. Figures shows that actual travel time is little higher than simulated travel time. The reason is that the road condition is not good and vehicles do not follow travel pattern, while in PTV Vissim, vehicles follow a travel pattern and run simulation randomly.

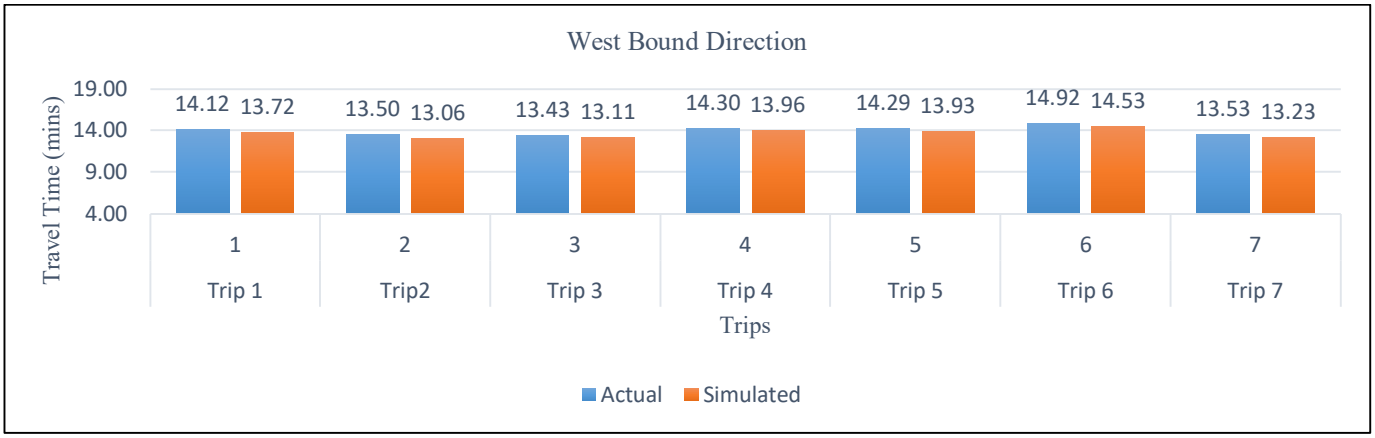

Fig 9: Actual and simulated travel time comparison

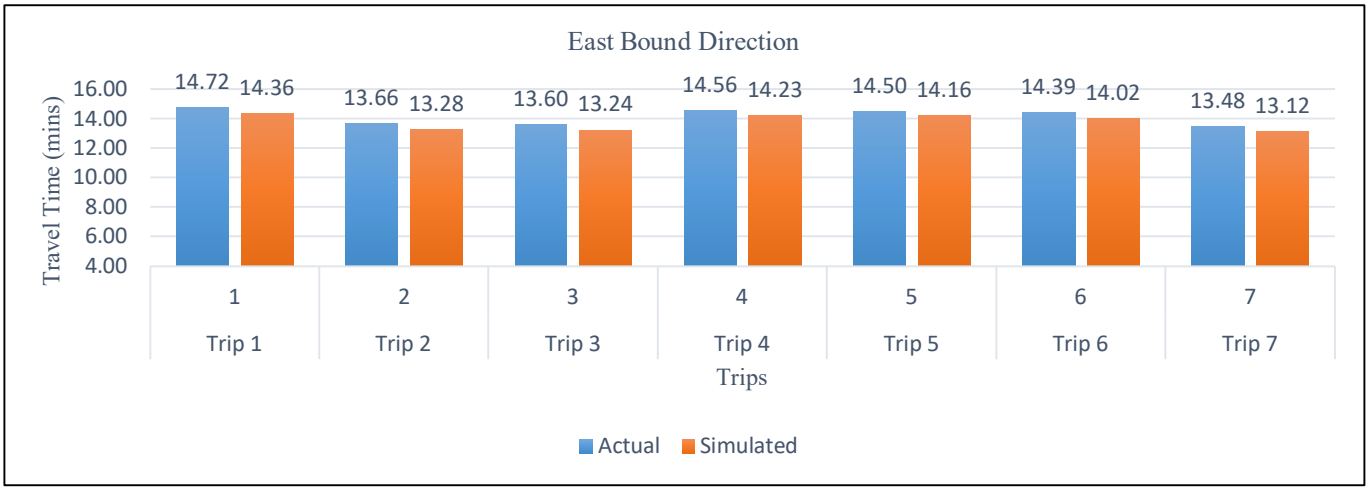

Fig 10: Actual and simulated travel time comparison

Fig 11 shows average travel time improvement of vehicles in west bound. Highest improvement in travel time is i.e., bike 12.47% followed by car/jeep 10.77%. Improvement in truck travel time is 7%.

Fig 12 shows average travel time improvement of vehicles in east bound. Highest improvement in travel time is i.e., bike 12.19% followed by car/jeep 11.06%. Improvement in truck travel time is 7.47%. Fig 13 shows facility wise average travel time improvement in west bound. By providing bus bays and pedestrian overhead bridge travel time improves 1.88%. By providing only slip lines travel time improves 3.59%. By providing flyover at most congested intersection travel time improves 3.67%. By providing all facilities combinely travel time improves 9.13%. Fig 14 shows facility wise average travel time improvement in east bound. By providing bus bays and pedestrian overhead bridge travel time improves 1.86%. By providing only slip lines travel time improves 3.65%. By providing flyover at most congested intersection travel time improves 3.68%. By providing all facilities combinely travel time improves 9.20%.

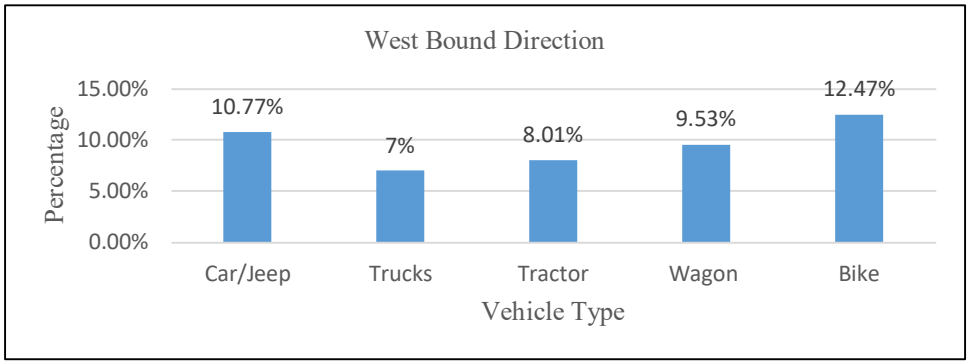

Fig 11: Category wise average travel time improvement in percentage

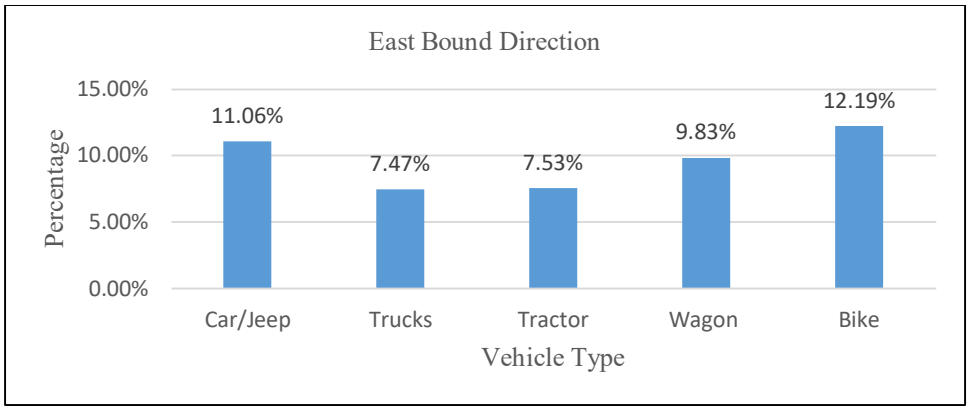

Fig 12: Category wise average travel time improvement in percentage

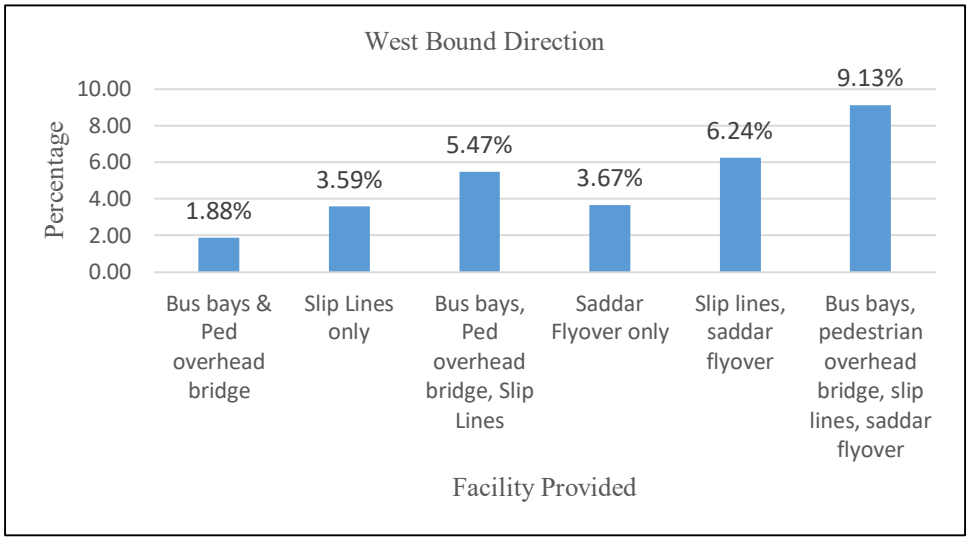

Fig 13: Facility wise average travel time improvement in percentage

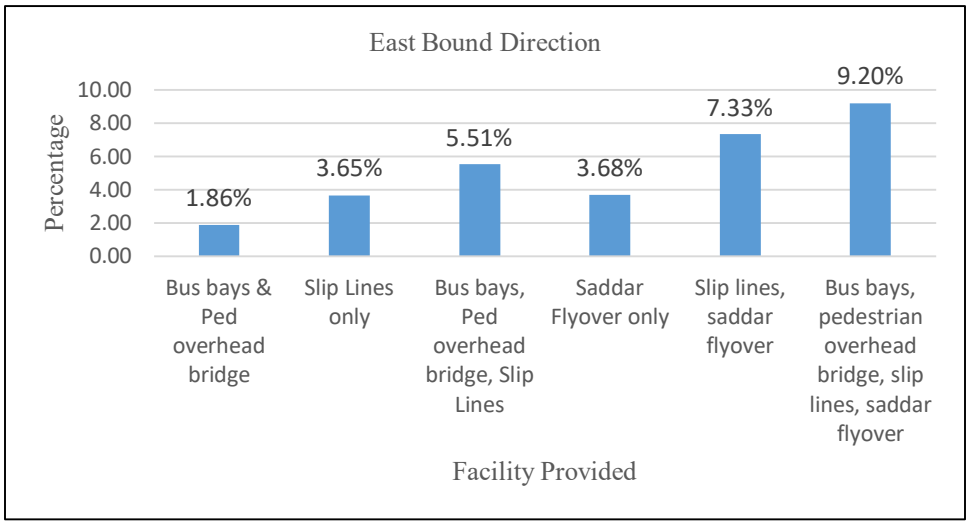

Fig 14: Facility wise average travel time improvement in percentage

VI. CONCLUSION

1) Different cities are taking different steps to control the congestion depending upon the traffic which include; Congestion pricing, Ring road development, construction of new roads, expanding existing roads, reducing the number of cars on the road, promoting public transport, biking and walking, parking management, Free public bus transport, Bus priority lane and bus priority signal system, Implementation of intelligent transport system (ITS) technology, Introduction of electric vehicles, digital ticketing system reduced the speed limit in the city center and dedicated bicycle lanes to prioritize access for cyclists and to enhance traffic safety.
2) The main reason of bypass failure in Pakistan is that bypass roads are not designed according to bypass standards. Main reasons are: Open access to bypass road due to which local traffic get easy access to bypass road. Movement of pedestrians, parking and stopping of vehicles can be seen at bypass roads. Road side development and land use are not controlled along bypass roads.
3) From the results obtained, it is clear that bypass roads functionality can be improved by providing different facilities i.e. pedestrian overhead bridge, bus bays, slip lines and flyover. West bound average improvement in travel time by providing all facilities is 9.13% while East bound average improvement in travel time is 9.20%. Similarly, average improvement in vehicles travel time at west bound is: (wagon 9.53%, tractor 8.01%, and truck 7%). East bound average travel time improvement of vehicles is: (wagon 9.83%, tractor 7.53%, truck 7.47%).

VII. RECOMMENDATION

At first, pedestrian overhead bridge, bus bays and slip lines are recommended as an economical solution. At the later stage, flyover is recommended as an uneconomical solution. For further research it is also recommended to try some other facilities for travel time improvement.

VIII. ACKNOWLEDGMENT

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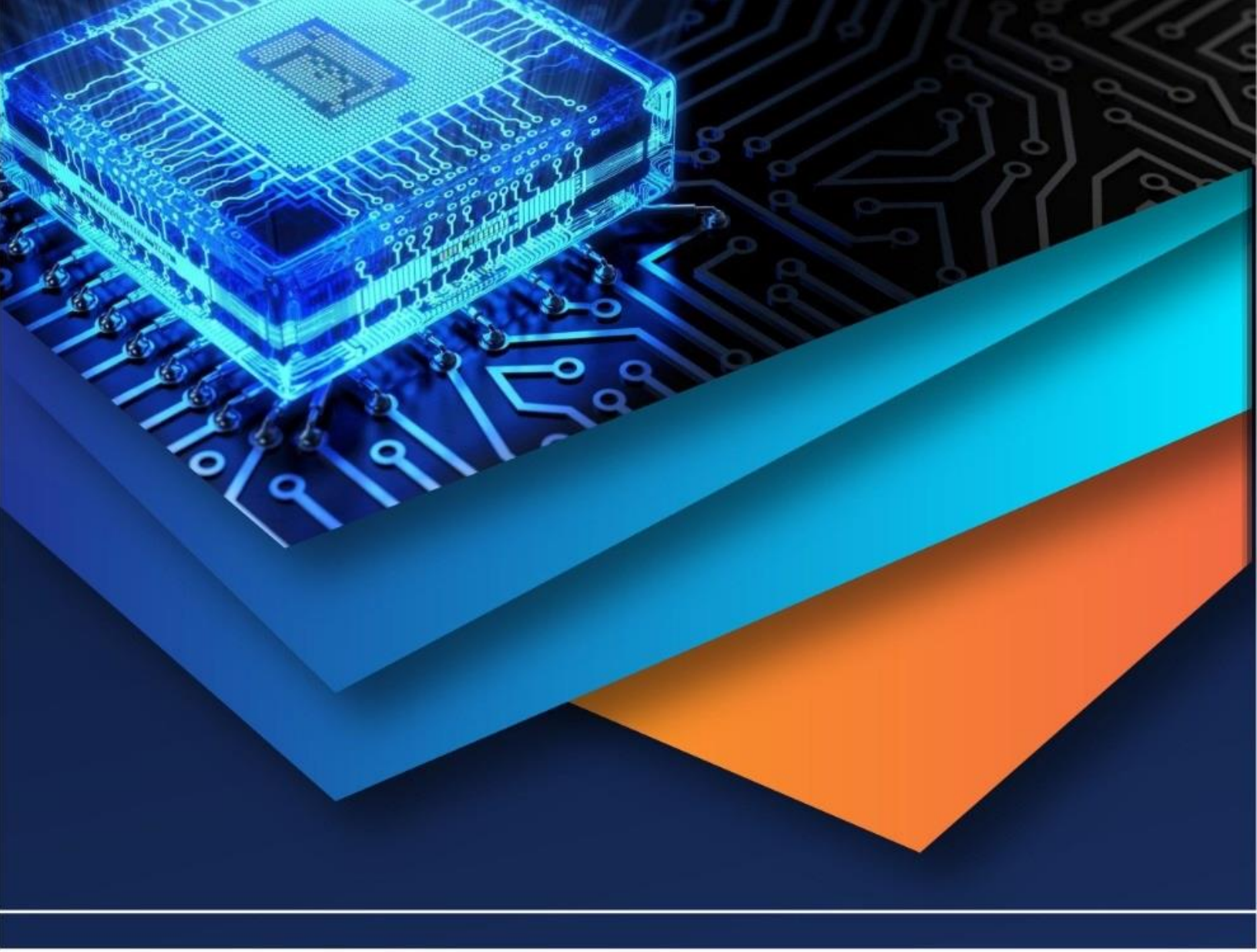

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