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Improvement in Level of Service (LOS) of Conventional Underpass

A Case Study of Jail Road Underpass, Lahore

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Abstract —*In this study the major geometrical d esign issues of Jail Road Underpass, Lahore has been highlighted. All the underpasses are constructed to favor the fast moving traffic/through traffic, which in case of Lahore city is right hand traffic. The jail road underpass has been constructed on the left hand side vilating the international design standards. This creates the potential hazardous conflict points posing serious threats to the safety of commuters.The aim of this study is to determine the existing Level of service of Jail road underpass and suggest suitable geometric design improvements to esure the smooth flow of traffic.*

Keywords- *Geometrical design, conflict points, underpass, traffic flow, Level of service, Jail road*

I. INTRODUCTION.

Lahore is the second major city of Pakistan and a major socio-economic and cultural focal point of Punjab; having current estimated population of more than 9 Mio. Every year the city quarters an additional one million visitors from the adjacent areas all along the Pakistan. The ever increasing population along with several demographic changes in Lahore during the recent years has increased the volume of traffic especially on the Canal Bank road. Passing through the heart of Lahore, the canal bank road serves as most efficient link between N-E parts of the city with S-W parts. The traffic volume on canal road has increased manifold due to increase in car ownership. On both sides of canal road the land use is mixed, for example some sections such as Dharampura underpass to the Mall Road underpass comprises residential area other regions like Jail Road underpass to the Muslim Town underpass educational/health institutions exists.

II. BACKGROUND.

The recent widening of the Canal Bank road has reduced the traffic congestion to a considerable extent but still during the peak hours long queues of motor cars can been seen on the road. Added to this are the bottle necks still exist and a case in point is the Jail road underpass. As per the international design standards/regulations the underpass provide through movement to the fast moving vehicles so they must be located in the fast lanes Whereas the Jail road underpass design is seriously deficient as it is situated in the slower/left lane. In lieu of this deficiency, the through traffic movement is disturbed and forcibly diverted to the left lane instead of flowing straight in the right lane. A diagrammatic representation of the design flaw in the Jail road underpass is given below figure-1.

Figure 1. The deficient geometry at the Jail Road underpass creates unnecessary weaving and safety hazards

It can be seen that for the through traffic moving in the right/fast lane, choosing to use an underpass (red lines) entails an abrupt change in lanes and move to the slower/left lanes, which warrant a serious clash situation and hazardous for vehicular traffic. This "weaving" generates a direct conflict with the traffic moving in the slow lane, which is enforced to dangerously traverse on to the right lane towards the at-grade-junction/intersection and directly conflicts with the fast-moving traffic moving towards the underpass barrel. Resultantly, the through/fast-moving traffic creates several conflict points with the slow moving traffic as shown in figure-2.

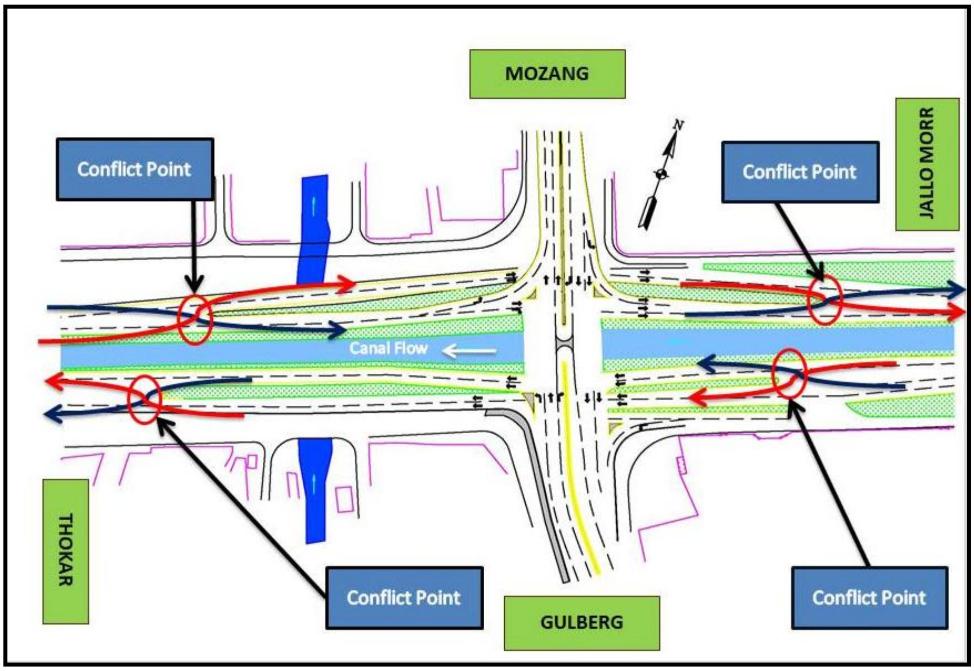

Figure 2. Traffic Weaving Phenomenon at Jail Road Underpass

III. STUDY OBJECTIVES.

The Jail road underpass was the first underpass to be constructed among other recently constructed underpasses on the Canal Bank road. But a serious design flaw exist which is the placement of the underpass barrel on the left or slow lane, the through traffic movement towards the underpasses is suddenly diverted to the left lane instead of flowing straight in the right lane. The objectives of this study are;

a. To analyze the existing traffic condition (LOS) of Jail road underpass section.
b. To propose a long term solution maintaining smooth traffic flow on the Canal Bank road particularly at Jail road underpass by suggesting some modifications in the geometric design.

IV. LITERATURE REVIEW.

The economic development of the country is directly related to well-developed transportation network. The growth potential of any economic system is greatly enhanced by improving the overall road network quality. The smooth functioning of a city's transportation network is highly dependent on traffic congestion. The productivity and time value is greatly reduced when the road users spends adequate time in traffic jams which in turn causes extravagant fuel expenditure and hits the overall economy of country. Thus construction of new roads along with routine maintenance of existing roads has long term economic paybacks.

4.1. Level of Service of Freeways

While talking about the service quality for drivers, the primary concern is the speed of maneuvering. Additionally the freedom of movement within in traffic stream and proximity to other vehicles is also a matter of concern. All of these qualities are highly dependent on density of traffic steam. As flow approaches capacity density increases as well, resulting in a measure of effectiveness that is sensitive to a wide variety of flow. Operating features for the six categories of Level of Service (LOS) are described below;

- **LOS A** defines free flowing operation of traffic stream. Prevailing speed is termed as free flow speed. Traffic stream is almost completely unhindered in their ability to maneuver. Incident effects and point breakdowns are easily absorbable in this level.

- **LOS B** signifies reasonably free flow and resultantly fee flow speeds are preserved. Slight restriction in the ability to operate within the traffic stream along with the provision of high level of physical and psychological comfort to drivers. Fair absorption of effects of minor incidents and point breakdowns.

- **LOS C** illustrates the flow speed at or near FFS of the freeway. Restriction in movement within the traffic stream. More care and vigilance is demanded on the part of driver while making a lane change. Incident absorption is very minor along with formation of substantial queues behind any blockage

- **LOS D** is the level at which speeds begin to decline slightly with increasing flows and density begins to increase somewhat more quickly. Freedom to maneuver within the traffic stream is more noticeably limited, and the driver experiences reduced physical and psychological comfort levels. Even minor incident can be expected to create queuing, because the traffic stream has little space to absorb disruptions at its highest density value.

- **LOS E** explains the traffic stream operation approaching capacity. No usable gaps are available in the traffic stream therefore the operations are relatively volatile. Speed exceeding 80km/h cannot be achieved as the vehicles are very closely spaced. Any disruption in traffic operations i.e. lane changing operation, entry and exit to ramp can create a serious disruption wave propagating throughout the upstream traffic flow. At capacity, no ability to dissipate the most minor disruption in the traffic stream and any incident can produce a serious breakdown which results in extensive queuing. Limited maneuverability along with poor physical and psychological comfort.

- **LOS F** simply describes overall breakdowns in vehicular flow. Queues start forming instantaneously where ever breakdown occurs

4.2. Overview of Past Studies

Mao, Yuan, Gan, Zhang (2019) conducted a study to evaluate weaving section efficiency in urban areas. The study incorporates the risk factors that are involved in traffic accidents at the weaving sections of urban road. Aim of this study is to provide solution to improve the safety of weaving section in PRC. The important factors that effects the roadway accidents at the weaving segment comprises of age and gender of driver, weather state, density of traffic at roadway segment, weaving ratio, operating speed, behavioral aspects of lane changing, number of cars (private), season, time & day of the week and accident location.

Another study conducted by Savitha, Satya Murthy, Jagadeesh, Sathish, Sundararajan (2017) on the evaluation of geometric features manipulating/controlling saturation flow rate at signalized intersections under the mixed traffic conditions. During the study fifteen signalized junctions were thoroughly studied in urban area of Bangalore. All the intersections have varied/mixed traffic parameters. Saturation flow rates were calculated by HCM 2000, IHCM-1997, and IRC (Indian Road Congress) SP: 41-1994 method and were compared with the field values. It was concluded that for better realistic values IHCM (Indian highway capacity manual)-1997 should be used because it provide better results for saturation flow rates.

Haosen Zhang (2019) studied the traffic organization of urban road combined intersection. The study aims to improve the urban road traffic intersections by reducing the number of traffic accidents and provide better/smooth travels to the commuters. It was concluded that the fundamental improvement can be done only when the authority take concrete steps to improve the traffic condition. Additionally the cooperation of commuters is also essential to achieve the desired results. All this will reduce the traffic pressure and improve the overall safety of road users.

Tobita, Naito, Nagatani (2012) studied traffic Flow Merging and Bifurcating at Junction on Two-Lane Highway. A model was presented for two lane highway depicting the vehicular motion at the junction. Actual jam condition occurring due to frequent lane changing was modeled for evaluation. Weaving condition was studied in detail using this model. It was concluded that the for smooth traffic flow vehicular flow, slow down speed and fraction of vehicles changing the direction plays a key role.

S. Fulekar, K.R Dahbekar and Balachandra Khode (2016) conducted a study to assess the Level of Service (LOS) of National Highways. The research uses the results of level of service calculated from HCS/HCM-2000 for metropolitan city of Nagpur. The variation in Level of service shows exponential trend for avg. spot speed & volume. Various highway midblock sections were evaluated using HCS-2000. It was noted that the Level of Service is a function of Speed and volume. The Level of Service starts deteriorating when the speed starts reducing resulting from increase in volume of traffic.

Msallam, Abojaradeh, Jrew, Al-Allaff (2016) conducted a study to evaluate traffic flow and traffic network management system in Jordan. .This research is an engineering project management study to improve traffic network management system in Al Shmesani district in Amman. It was conducted on a network of two main arterials with eight signalized intersections. Two alternatives were proposed to mend the Level of service of existing network. LOS was calculated using HCS and SYNCHRO for both existing condition and future predicted traffic.

V. METHODOLOGY

The baseline data of traffic count is acquired from Engineering Consultancy Services Punjab (ECSP). The data for Base year was processed to calculate the current year traffic. This traffic was used to calculate the PCUs. Ultimately the LOS was calculated using Highway capacity software. The following flow chart represents the brief methodology of whole study:

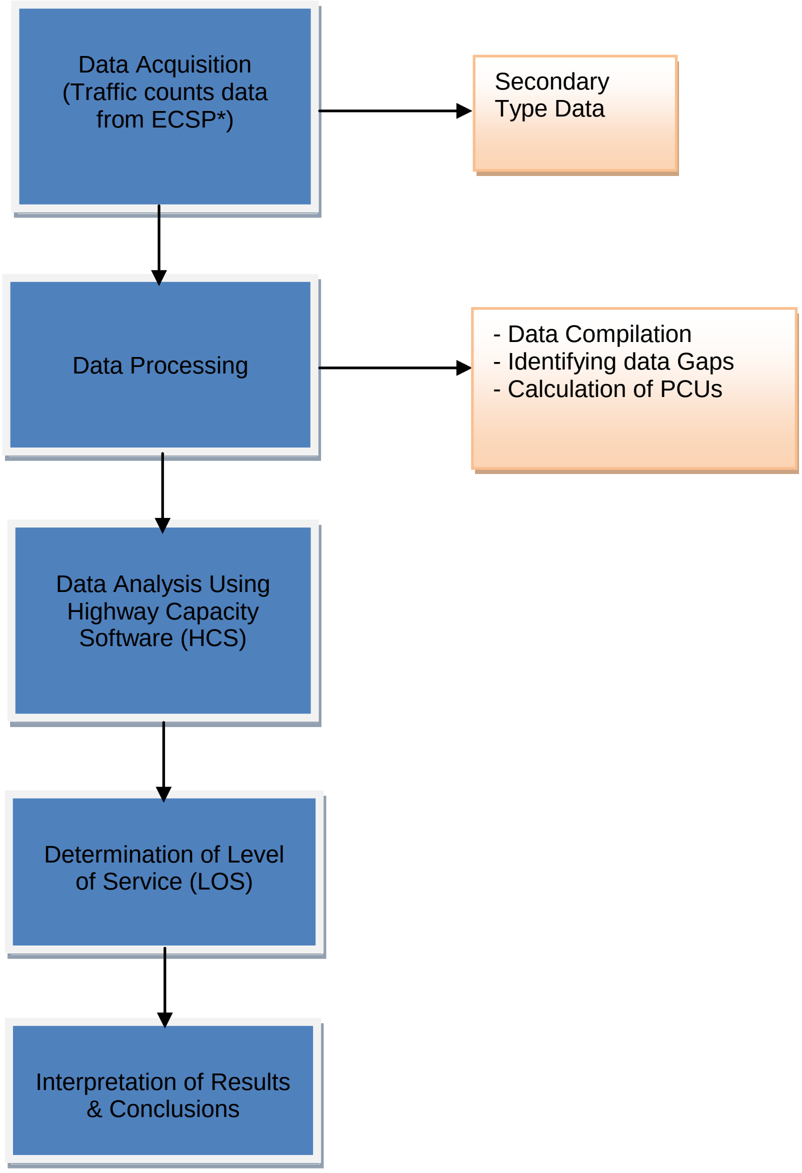

Figure 3. Flow chart representing the Methodology

VI. Analysis and Results

To study and analyze the traffic condition the traffic count survey conducted by ECSP in 2012 is used as baseline. The baseline traffic was converted in to Passenger Car Unit (PCU) using PCU factors presented by JICA in its report titled **"The Project for Lahore Urban Transport Master Plan in the Islamic Republic of Pakistan, Volume-II (2012)"**. The peak hour volume for 2012 is then projected to calculate the current year traffic using growth rate of 3.5%/year as shown in table-1. Level of Service (LOS) is then evaluated to understand the problems and determine potential solutions. For Jail road underpass LOS was calculated for year 2019. The results helped to assess the limitations of existing arrangement of the intersection and propose suitable solutions.

Table 1. Projected Peak Hour Volume (2012-2019)

Sr. No.	Direction	Description		Peak Hour Volume (PCU)						
			Base year (2012)	2013	2014	2015	2016	2017	2018	2019
1	D-1	Thokar to Gulberg	1,164	1,204	1,247	1,290	1,335	1,382	1,430	1,481
2	D-2	Thokar to Jallo	277	287	297	307	318	329	341	353
3	D-3	Thokar to Jallo(Under-Pass)	5,378	5,567	5,761	5,963	6,172	6,387	6,611	6,843
4	D-4	Thokar to Mozang	1,307	1,353	1,400	1,449	1,500	1,552	1,607	1,663
5	D-5	Gulberg to Jalo	1,132	1,172	1,213	1,255	1,299	1,344	1,392	1,441
6	D-6	Gulberg to Mozang	3,186	3,298	3,413	3,533	3,656	3,784	3,917	4,054
7	D-7	Gulberg to Thokar	1,270	1,315	1,361	1,408	1,458	1,508	1,561	1,616
8	D-8	Mozang to Jalo	932	965	998	1,033	1,070	1,107	1,146	1,186
9	D-9	Mozang to Gulberg	3,418	3,538	3,662	3,790	3,922	4,059	4,202	4,349
10	D-10	Mozang to Thokar	703	728	753	780	807	835	864	895
11	D-11	Jallo to Gulberg	405	419	434	449	465	480	498	515
12	D-12	Jallo to Thokar	278	288	298	308	319	330	342	354
13	D-13	Jallo to Thokar(Under-Pass)	5,412	5,601	5,797	6,000	6,210	6,427	6,653	6,885
14	D-14	Jallo to Mozang	932	965	998	1,033	1,070	1,107	1,146	1,186

6.1. Traffic Analysis

The baseline trafiic data from ECSP was used to predict the future traffic for year 2019 using growth rate of 3.5%. For Traffic analysis purpose "Highway Capacity Software/Manual (HCS 2000)" was used. Two main aspects of Traffic Flow were analysed at the Jail road intersection and are mentioned as below;

- **Traffic analysis at weaving segment**
- **Traffic analysis at Underpass**

6.2. Traffic Analysis of Weaving Segment

The HCS analysis shows that due to the weaving effect, vehicles moving from Thokar to Jallo have to reduce their speed from 60km/h to 34.2 Km/h. The computed figure for density is 87.22 PC/km/lane. For the traffic moving from Jallo to Thokar, at weaving segment the speed gets reduced to 35.7 Km/h which is a result of weaving. Density increases to 84.36 PC/km/lane as mentioned in Table 2.

Table 2. Traffic analysis at weaving segment using Highway Capacity Software

Sr. No.	Direction	Peak Hour Volume (P.C.U)	Speed Km/h	Density PC/Km/l	Level of Service
1	Thokar to Jallo	9926	34.2	87.22	F
2	Jallo to Thokar	8937	35.7	84.36	F

6.3. Traffic Analysis of Underpass

For the traffic analysis at underpass, peak hour traffic in both directions passing through the underpass was considered. The density of traffic for both the directions comes out to be greater than 29 resulting in failure of level of service of underpass. This shows that existing two lane underpasses reach its full capacity during peak hours. Table 3 summarizes the results of HCS for Jail road underpass.

Table 3. Traffic analysis at underpass by Highway Capacity Software

Sr. No.	Direction	Peak Hour Volume (P.C.U)	Density PC/Km/l	Level of Service
1	Thokar to Jallo	6843	>29	F
2	Jallo to Thokar	6885	>29	F

VII. CONCLUSIONS

Various options and corrective measures have been considered while studying the existing issues at the Jail road underpass. The options listed from figure 4 through 6 are based on the analysis of traffic data and with the objective of improving the capacity and speed for the commuters.

- **OPTION – I:** To shift the left turning lanes from right side of the existing underpass to left side.

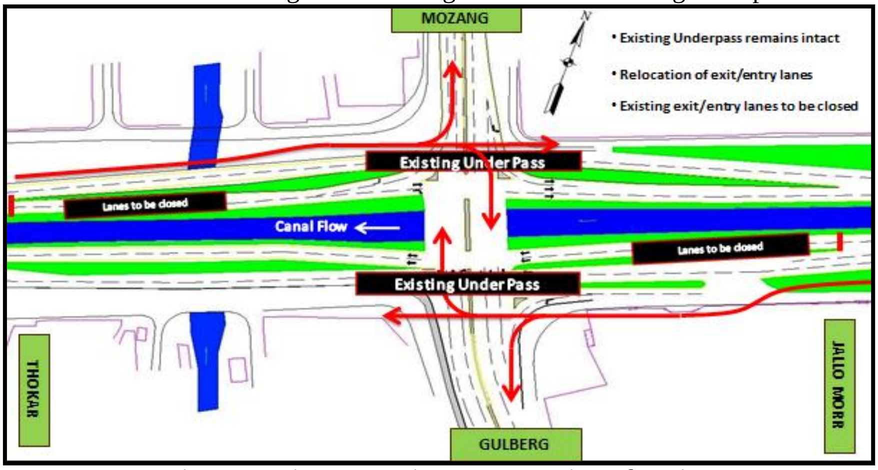

Figure 4. Diagrammatic Representation of Option-I

- **OPTION –II*:*** Relocation of at grade turning lanes to left of existing underpass & widening of existing underpass.

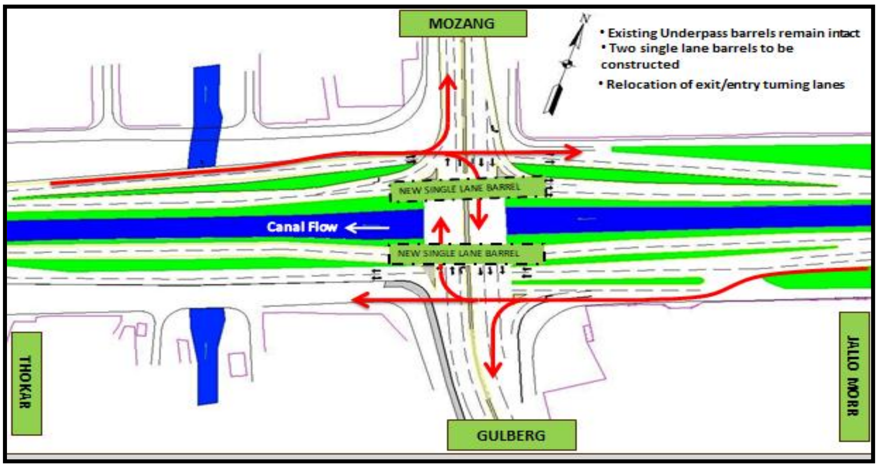

Figure 5. Diagrammatic Representation of Option-I

- **OPTION –III:** To shift the left turning lanes from right side of the existing underpass to left side.

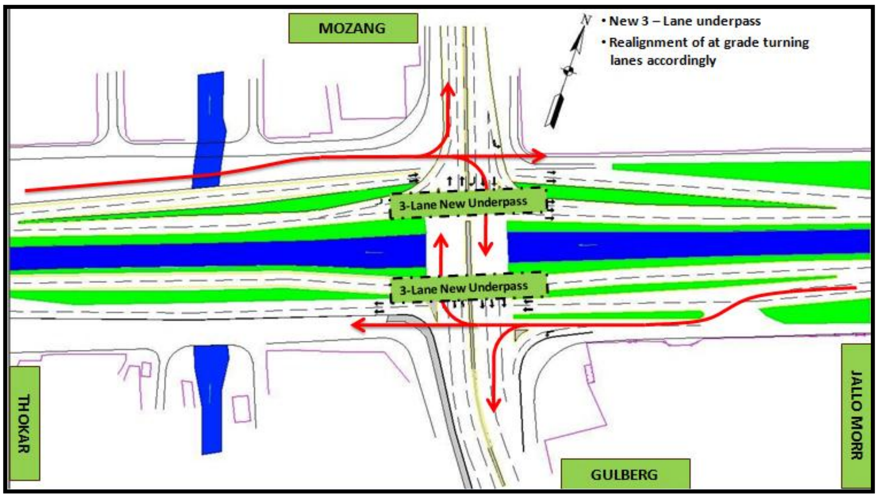

Figure 6. Diagrammatic Representation of Option-III

The aforementioned options are based on the improvements in various Geometric parameters of the jail road underpass. Final decision depends on various factors like underpass capacity, traffic flow parameters, LOS of underpass and cost to be incurred in execution (cost estimation is not park of study). Final recommendations are discussed in next chapter.

VIII. RECOMMENDATIONS.

The analysis conducted on the existing traffic condition for current year 2019 and it was revealed that the existing arrangement fails to serve the purpose due to excessive weaving/lane changing behavior of traffic. This fact is evident from the HCS results both for through movement and weaving section.
From the traffic analysis and options discussed it can be seen that the best available options for the improvements to be carried out at the Jail road underpass is;

- To construct new underpass (3 – lanes) and associated arrangements.

Both the omission of Weaving sections and enhancement in capacity of underpass can be achieved by implementing this option. All this will ultimately improve the overall LOS of the facility.

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