

AN ANALYSIS OF ENVIRONMENTAL ADVANTAGES OF FLYOVER CONSTRUCTION OVER SIGNALIZED JUNCTIONS: A CASE STUDY OF TAKHTBHAI FLYOVER

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Abstract

Rapid urbanization and gradual rise of motorized transport in the developing regions have played a crucial role in aggravating traffic congestion, consumption of fuel and emission of vehicular emissions posing a deadly concern to the environment and human health. The paper analyzes the environmental benefits of building a flyover as opposed to the use of signalized at-grade intersections based on the Takht Bhai Flyover in Takht Bhai. The study compares the level of grade separation in minimizing traffic delays, vehicle idling, fuel wastage, and pollutants emission to the previous synchronized traffic signal system at four major junctions in the main market area in the town. Primary data were gathered using a mixed-method design by using the counting technique of traffic counts at various entry and exit points, and classifying vehicles into passenger car unit (PCU) equivalents, travel time was measured, vehicle speeds were measured over a 2-kilometer distance, and the fuel consumption during movement and idling were estimated. Peak-hour measurements were carried out to determine the length of the queue, the cycles of delays and the alteration in the traffic density just prior to and after the construction of the flyovers. The results show that about 35-40 percent of the total traffic volume became redirected to the flyover leading to a decrease of the vehicle delays up to 30 percent and a significant increase in the average traveling velocity which reduced the time spent in idle conditions at intersections. This also led to decrease in idling which directly resulted in fuel consumption and a quantifiable decrease in vehicular emissions and this is an advantage to the environment of continuous traffic flow. The research also takes into account accident statistics and cost of operation, which shows that the mobility and economic efficiency improved, but there are some safety issues and the use of fixed-time signal control at the ground level which restricted the performance at its best on the secondary roads. Generally, the study finds that although flyover construction has a great impact on improving traffic movement and the environmental load in the fast-growing urban centres, its maximum benefits can be achieved only when it is combined with the enhanced traffic regulation systems and new signal control systems.

1. INTRODUCTION

1.1. Background of the Study

For a huge number of megacities/major metropolitan centres, primarily in developing nations, “urban air pollution” from motor travel is becoming an increasing concern. Road transport has been identified as the main cause of pollution, accounting for 50% to 90% of overall air pollution in these cities. Air pollution has been found to have substantial short- and long-term health consequences. Eye irritation, dizziness, nausea, wheezing, headache, weakness and numbness, chest tightness, and other short-term symptoms are common. Persistent cough, lung cancer, asthma, respiratory infections blood problems and other long-term consequences are possible. Air pollution can lead to a decline in activity/performance, a hike in emergency department visits and admissions in hospitals, and even mortality in rare situations. Because there are so many various sources and types of pollutants, the consequences of air pollution on health are quite complicated. People who are poor, undernourished, very young and very old, and those who have pre-existing respiratory disorders or other health problems are especially vulnerable. The negative consequences of air pollution on one's health have been thoroughly documented. (ESMAP 2004; Anon; WHO 2003, 2004; Godish 2004)

The traffic and vehicular pollution in Takhtbhai, Mardan, are getting worse by the day, owing to the city's inability to handle the amount of cars on the road. The problem will worsen unless the surface ministry develops a stronger strategy for dealing with it. The common man is developing an antipathy to short-sighted policymakers, hoping that they will devise some preventative policies and related activities. Let us look at this subject from several angles: -

There is a significant disparity between the amount of new automobiles entering the market on a daily basis and the existing infrastructure. This gap is far larger than predicted by state governments in terms of the infrastructure needed to accommodate these vehicles on the road. Furthermore, they contribute to traffic congestion, vehicle pollution, and, of course,

respiratory ailments, as the Times of India has already mentioned. Lastly it also uses tremendous resources in terms of petrol and diesel.

The only way to address this issue is to enhance public mass transit and make it a more appealing alternative for medium and higher middle-class people who drive small and mid-size automobiles to work. This would go a long way in saving resources and combating environmental challenges in metros like Peshawar. It simply takes common sense to realise that those who are used to travelling by car will only convert to public transportation if the choice is easy, pleasant, and easily available.

Cities are expanding their limits, both horizontally and vertically, as income rises, to accommodate an increasing number of people and activities. As a result, the usage of motorised transportation is likely to rise steadily in the next years, perhaps causing air pollution to deteriorate. In megacities/large urban centres, particularly in developing nations, the need to address the impact of air pollution from transportation operations is widely recognised. Increased use of transportation activities frequently causes traffic congestion, especially in urban areas such as commercial activity zones. Commuters and residents in the surrounding areas are subjected to high levels of air pollution emitted by vehicles passing through congested areas and/or waiting for traffic lights to turn green. It is necessary to make an effort to reduce the amount of time spent waiting at traffic signals. According to Mandavilli et al. (2003), modern roundabouts can increase traffic flow as well as reduce vehicular emissions and fuel consumption by reducing vehicle idle time at intersections, resulting in a beneficial environmental impact. Where a roundabout is not possible owing to space constraints, the installation of flyovers over busy traffic roads is regarded an effective technique of guaranteeing smooth traffic flow and minimizing unnecessary delays. It also aids in decreasing vehicle emissions and needless fuel (petrol/diesel) combustion while waiting for a signal or traffic to clear. In order to alleviate traffic congestion, a great

number of flyovers have been built or are being built in major urban areas around the world.

The impact of constructing a flyover over four signalised crossings in a busy/main market area of Takht Bhai will be examined in this proposed research. It's worth noting that there were roundabouts at two of the four locations prior to the flyover, but due to the significant increase in traffic volume in the area, those roundabouts had to be demolished. The traffic signals are synchronised, which means that if a vehicle receives a green signal on the first signal, it will also receive a green signal on the second signal, and so on, and vice versa. When a vehicle approaches a crossroads, the worst case scenario is that every light is in the red phase. Idling produces the greatest quantity of pollutants at that time. The benefits of the flyover's construction will be calculated in terms of traffic reduction/relief, pollution reduction, and time savings.

1.2. Details of the study area; TAKHT BHAI

The people of northern Khyber Pakhtunkhwa (KP) breathed a sigh of relief after the federal government completed work on the long-delayed Takht Bhai flyover in Mardan district, as they will no longer have to endure massive traffic jams, which have been a common sight in the area since the project began.

The flyover, which was erected over a railway crossing on the Nowshera-Chitral Highway (N-45), is available to all types of traffic and will benefit almost seven million people in KP's seven northern districts.

Arshad Khan, the project director for the Takht Bhai flyover, told reporters that the National Highway Authority had recently completed work on the much-delayed project (NHA).

The Pakistan Muslim League-Nawaz (PML-N) government launched the project to help residents of 11 districts: Malakand, Upper Dir, Lower Dir, Chitral, Swat, Shangla, Mardan, and Bajaur Agency.

According to Arshad Khan, the project will enable people in Malakand division get faster connection while also saving them time while driving to Peshawar or Islamabad without having to worry about traffic jams.

The contract for the Takht Bhai flyover was won on November 28, 2012, and work on it began on February 6, 2013, he said.

Khan went on to say that the bridge was supposed to have 9 pillars in the original design, but that the officials increased it to 24 pillars. The flyover is approximately 609 metres long and 9.3 metres wide, with a maximum length of 9 metres at the railway crossing, according to him.

Along with the service road, towering electrical poles were placed across the bridge to provide lighting services to drivers and motorists. Prior to its completion, commuters and residents of Takht Bhai and its surrounding districts had been experiencing significant difficulties as a result of the project's persistent delays.

Through seamless communication, the initiative would assist enhance tourism in Malakand division, including Swat, as well as commerce and business operations throughout the region.



1.3. Research problem

The researchers' job is to look at the effects of putting a flyover over four signalised crossings in Takht Bhai's major market area.

1.4. Significance of the Research

The research study is significant, because it enhances our insight into the understanding of the problems of traffic rush. It will create awareness among the scholars as to how a problem like this can be explored to establish a settlement to live in a completely different comfortable zone. This study will also broaden the critical vision of the scholars of the concerned subjects regarding the various issues of roads and will prove a source of guidance for future researchers in the field.

2. Literature review

Literature review is the backbone of the research process because it presents and expresses the views of other critics and researchers. It shows what is already done in the field and what needs to be done. It highlights the research gaps.

There would be no need for a flyover if there was infinite right-of-way because conventional interchanges could be built, which give more at-grade capacity than flyovers. A minimum clear width must be available within a restricted right-of-way. That constrained cross section must accommodate the appropriate number of lanes, both on the flyover itself and at grade for structure appurtenances and lateral safety

clearances comparable to those found on the arterial.

"Multan had three operating flyovers as of May 20, 2011, with nine more planned (The Express Tribune, 2011). By December 1, 2013, a total of 44 flyovers in Karachi were either operating or planned to be built (Maher, 2013). In Lahore alone, three new flyovers are scheduled to be built in 2021." (Hasnain, 2021).

"Five flyovers were completed in Karachi in 2007, five more in 2008, and six more in 2009". (Maher, 2013). Politics plays a role in the construction of flyovers in Pakistan, as public-facing infrastructure projects in city centres increase politicians' approval ratings (Shah, 2016). Investing in alternative development projects, on the other hand, could have a greater societal benefit.

Time savings: One advantage of flyovers is the potential for increased labour productivity due to reduced time wasted due to traffic congestion. As a result, motorists' fuel-related expenses are reduced. Pakistan's GDP per capita, on the other hand, is US\$1,194, compared to US\$40,285 and US\$63,544 for the United Kingdom and the United States, respectively (The World Bank, 2021). As a result, the value of improved output as a result of time saved through flyovers in Pakistan may be negligible.

Another benefit of flyovers is that they reduce car pollution by easing traffic congestion. A reduction in air pollution can improve residents'

health and productivity, reducing the need for sick leave, in addition to the positive environmental impact. Because air pollution causes "one-third of deaths from stroke, lung cancer, and heart disease," a reduction in air pollution can improve residents' health and productivity, reducing the need for sick leave (WHO, 2018).

While this is not feasible at every overpass, toll plazas can be built up to generate a stream of revenue to partially or completely fund the project. The Habibabad overpass toll plaza is expected to earn PKR 5.51 billion in revenue, more than six times the project's cost (Public Private Partnership Authority, n.d.).

Furthermore, the increased construction of flyovers aids the construction sector's expansion, which boosts the country's GDP per capita and general standard of living.

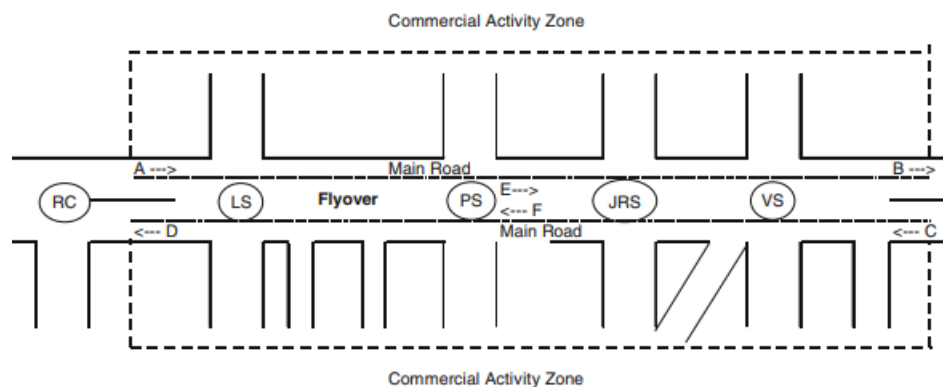
The cost of a private flyover is governed by factors such as the length and number of lanes, geographical constraints, material quality, and project completion time. For example, the Habibabad flyover in Islamabad cost PKR 831 million in 2015 (Public Private Partnership Authority, n.d.), the Bhara Kahu flyover in Islamabad cost PKR 500 million in 2020 (Abbasi, 2020), and the Sheranwala Gate flyover in Lahore cost PKR 4.9 billion in 2021 (Public Private Partnership Authority, n.d.). (Abbasi, 2020). Hasnain (Hasnain, 2021).

3. Methodology

The study at hand detailed the method for acquiring primary data on traffic movement, evaluating time savings, and assessing pollutant load on a 2-kilometer stretch of road. Fuel consumption while driving and idling at traffic lights were also calculated. The cost of avoidable fuel loss due to idling will also be calculated and provided in the proposed study.

3.1. Traffic count

"The traffic movement at both ends of the flyover were manually counted on an hourly basis for a period of 12 hours between 9 a.m. and 9 p.m. On the main road, the traffic count places are labelled A, B, C, and D, and on the flyover, E and F, with their corresponding information. Two-wheelers (2W), three-wheelers (3W), four-wheelers (4W), and light commercial trucks (4W) were split into four classes (LCVs). Heavy-duty diesel vehicles (buses, trucks, etc.) are not permitted to utilise the flyover. An hourly average traffic density will be determined for the 12 hours of the traffic count period. After a 13-month gap, a traffic count will be done to examine for differences in traffic density and to determine the volume of traffic diverted to the flyover on various dates. Traffic will be counted for a limited time period during peak hours, and the results will be compared."



3.2. Travel time and vehicle speed

An electronic timer was used to determine the time it takes to drive from Malakand division to Mardan district and return via "the main road

and the flyover during morning peak traffic times (between 10:30 and 12:00 hrs). On both sides of the main road and over the flyover, the time it takes to go from one spot to another will be

recorded three times each.” The timer will begin when the RC signal is crossed and end when the GC signal is crossed. On the opposite side of the road, the timer will start again shortly after passing through the GC signal and will finish just before reaching the RC signal. The observations will be made over the course of three working days, utilising various 4-wheelers operated by various drivers. Following a 45-day break, the second time observations will be taken, and the third time observations will be taken two days after the second time observation.

For each observation, the amount of time spent idling owing to a traffic signal will also be recorded. “ $V=D/T$ will be used to calculate the vehicle's average speed (km/hr), where V is the vehicle's speed (km/hr), D is the distance (road length in km) traversed by the vehicle (2 km in this case), and T is the overall journey time (hr), whether on the main road or on the flyover.”

For each of the three days' observations, the recorded journey time and estimated average vehicle speed will be plotted. It will be calculated what the standard deviation is.

3.3. Organization of the study

Chapter 1 Introduction

Chapter 2 Literature review

Chapter 3 Research methodology

Chapter 4 Data analysis and Discussion

Chapter 5 Conclusion and Recommendations

4. Data analysis and Discussion

Under the bridge, “traffic is tallied at each leg/direction that cars enter the intersection, at sites designated as 1, 2, 3, and 4, and on the bridge, traffic is counted at spots marked as A, B, C, and D. The vehicles were divided into five categories: 2-wheelers, 3- and 4-wheelers, 6-wheelers, buses, and heavy-duty vehicles. The unit factor 0.33, 1.0, 1.75, 2.25, and 2.25 are used to convert traffic volume to equivalent passenger car

unit. On three peak periods, the timing of vehicle delay and queue length is counted in a cycle phase time of traffic light. The traffic signal programmes used the same control as the at-grade intersection situation, with 4 out of 5 case studies controlled by a fixed-time control plan throughout the day.”

Accident statistics for each area were obtained over a three-year period (2010-2012) from three Thai agencies: the Department of Highways (DOH), police records, and Emergency Medical Services (EMS). The figures were utilised to calculate the costs of accidents that happened at these existing sites. Table 3 illustrates the number of fatalities during a three-year period. Eq. (1) was used to calculate the yearly average accident cost in order to illustrate the combined consequences of the number and severity of accidents in these case studies.

Although the placement of a flyover bridge improves junction control, “it still has numerous limitations and cannot fully solve the traffic problems that exist in comparable situations of the at-grade intersection model, such as vehicle delay, traffic congestion, and road accidents. While under the bridge, the same traffic management plans as “before the flyover” were still in operation. Despite the fact that about 30-35% of total traffic volume was redirected to the bridge and vehicle delays were decreased by 30% during the same period, the traffic flow condition on the secondary road is nearly identical to that of the prior at-grade crossing.” The fixed-time cycle plan of traffic signalization was employed to regulate traffic volumes at ground level (4 out of 5 case studies used just one control plan throughout the day), resulting in unnecessary vehicle time waste. Table 5 goes through the concerns discovered in this study about the flyover approach, including its benefits and drawbacks.

Advantages and disadvantages of the flyover intersection

Items	Disadvantages	Advantages
The bridge over an atgrade level	“The visual landscape is obscured, especially the commercial building that located near this area”	Convenient for road users using the bridge, free flow on the bridge
Traffic capacity	“Small increase in traffic capacity for the secondary road”	- Empowered to handle large traffic volume, especially on the main road
Delay & Queue length	“The delay and queue on secondary road are quite the same as the situation of the atgrade intersection”	“Reducing a number of delays and vehicle queues in the direction of the bridge constructed (main road) - Saving travel time, increasing vehicle speed, especially, on the main road from 29.8 km/hr. to 52.5 km/hr. at 85% vehicle speed”
Traffic control	“Traffic signalization still uses the fixed-time control plans as the previous situation of atgrade intersection, which does not fully utilize the benefits of having a flyover”	“Reducing time for waiting at the intersection (by adjusting a new cycle time for flyover situation”
Road Safety	“In the flyover area, the hazard zone is spread to more zones, especially at the approaching and exiting zones of the bridge”	“Reduce traffic conflict points at the junction Reducing rear-end collisions”
Cost and benefit	“During construction, road accidents and vehicle time delay incurred extra costs - Higher maintenance costs”	“The flyover is an essential part of the highest type of highway, the expressway or freeway. It has cheaper construction cost than other types of grade separations. No land needs to be expropriated.”

According to the physical data, “the area of intersection has increased compared to the old one and under the bridge, the existing traffic signalization still uses the same previous fixed time control plans; hence, similar problems as those of the previous at-grade intersection still exist. Furthermore, the hazardous zone has spread to other zones in the flyover area, as follows: At the bridge's approaching and exiting zones (bottleneck); road users' behaviour at an approaching zone may result in weaving conflicts due to vehicles cutting in sharply from the right

lane to the left lane before entering the auxiliary lanes or heading for the bridge. At the exiting zone, conflicts of vehicles merging can lead to road crash because some vehicles from the left auxiliary lane cutting across the chevron markings to the right lane of the main road abruptly. When a high speed vehicle on the main road passes this area, a crash may happen as a result of the vehicles on the main road hitting the motorcycle emerging from the drainage median. At the beginning of the bridge, there are illegal

paths that were used by motorists to cross to the opposite direction.”

The U-turn beneath the bridge is situated around 17 metres, or three car length, from the stop line markings on the bridge direction. This type of U-turn, which permits traffic to move in both directions and turns into a prohibited path for motorcycles in the Udon Thani case study, may result in head-on collisions, right-angle collisions, and collisions at an angle. “On the shoulder of the road, there are many heavy trucks that stop and wait for repair and recess. Some incidents may occur when motorcycles using the shoulder at night time and cannot see a truck in time, a rear-end collision could result.”

Due to the lack of a common design for the flyover model, there are additional issues close to the flyover area. The Takhtbhai case study uses a new type of traffic control, such opening up a U-turn on a side road. A supermarket may be found close to the flyover position, and the U-turn on the other right side lacks an extra lane. Eq. (1) is used to calculate the annual average accident cost in order to evaluate the accident cost at the current flyover crossings. The authors used an estimate provided by Dr. Nima Asgari, who stated that “every crash of road accidents in one year will be one person's death, injured 20 people, and 1 of 20 people become to a disabled person,” so if there are 100 injured people, 5 people may become disabled. This is because the accident statistics from the 3 agencies did not record the number of people who were disabled by the accidents. This research calculates the number of impaired persons as 5% of the mildly injured number. A sophisticated micro-analytical tool, this programme is used to assess various junction designs in terms of their capacity, level of service, wait time, queue length, as well as fuel consumption, pollutant emissions, and operational expenses. The programme was utilised in this study to evaluate each flyover-improved intersection's performance and to highlight the average delay, average queue length, and service quality. Additionally, the same data were utilised to determine the ideal cycle-phase durations using the smallest time delay as the

indication in order to further enhance the performance of the junctions.

5. Conclusion

This study, which is a component of the author's thesis, highlighted issues with road safety and its effects in flyover regions in comparison to the “before” condition. - An advanced micro-analytical tool called the Signalized (and unsignalized) Intersection Design and Research Aid is used to assess various intersection designs in terms of their capacity, level of service, and a variety of performance indicators, such as time delays, queue lengths, fuel consumption, pollutant emissions, and operating costs. This study which is one part of the first author's thesis, presented the performance of one of the case studies flyovers and suggested improvements to flyover intersections in Takhtbhai. An at-grade intersection was upgraded with an installation of a flyover at a cost of about millions, to increase capacity of the intersection and reduce vehicle delay and long queue at the at-grade level, the flyover is one of the methods that supported traffic volume about 25,000- 45,000 vehicle/day. “A case study of an at-grade intersection converted to a flyover intersection was the subject of the author's second study, which focused on the benefits. It was discovered that 35-40% of the total traffic volume was diverted to the flyover, and that despite a +29.46% increase in traffic volume at the intersection, vehicle delays were reduced by 30.41% over the same period, saving millions of dollars in travel time and vehicle operation costs. However, the study's findings indicate that fixed time management plans have been used to manage traffic signalization for both the enhanced flyover scenario and the current at-grade condition. There are still significant delays, particularly on secondary routes. In addition, the conflict spots rose from 50 to 64, and hazardous zones in the flyover area expanded to include zones at the arriving and departing regions, at the drainage ditches on a road median, at the U-turn under the bridge, and at the crossroad under the flyover.” The average annual cost of an accident at a flyover crossing is roughly a million rupees,

with 30 collisions, 30 victims, and 1 fatality. The SIDRA programme (version 5.1) was used to determine the ideal cycle-phase timings based on the least amount of time delay in order to enhance the performance of the flyover crossings. The Road Safety Inspection guideline was used for site inspections and suggestions with regard to improving road safety.

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