EUROPEAN ACADEMIC RESEARCH
Vol. II, Issue 11/ February 2015

ISSN 2286-4822
www.euacademic.org

Impact Factor: 3.1 (UIF)
DRJI Value: 5.9 (B+)

An Economic Analysis of Improvement of Road Infrastructure: A Case Study

Dr. DIPTI RANJAN MOHAPATRA
Associate Professor (Economics)
School of Business and Economics
Madawalabu University

Abstract:

A well-developed transportation network is vital to the economic development of the country. High quality road network increases the potential of any economic system by helping both consumer and producer. Traffic congestions are major bottleneck of smooth functioning of a city transportation network. With increase in vehicle population commuters spends more time in traffic jam and loses precious time which could have been utilised in productive activities otherwise. It also causes wasteful fuel expenditure which directly affects the country's exchequer. Thus creation of new road infrastructures as well as periodic maintenance of the existing one has long term economic benefits. The economic benefits are calibrated by carrying out cost-benefit analysis of the expenditures incurred and benefits created vide Economic Internal Rate of Return (EIRR). The bustling city of Chandigarh is always frequented with heavy traffic jam due to ever increasing vehicle population. In order to sort out the traffic problems in the city, the engineering department of Union Territory of Chandigarh is building-up one flyover, one bridge and three underpasses at various locations of the city. Here an attempt has been made to carry out an economic analysis of the above-mentioned projects. A factor of 0.85 has been adopted to convert financial costs into economic costs. The EIRR for flyover is estimated to be 15.57%, bridge to be 21.05%, underpass between sector 9 &17 to be 15.05%, underpass between sector 34 & 35 to be 14.14% and underpass between sector 22 & 35 to be 14.16%. The sensitivity analysis also proved the economic viability all the projects. Overall the proposed investment programmes are economically viable.

Key Words: EIRR, economic viability, sensitivity analysis, traffic congestion, Idling fuel consumptions, time savings

1.0 Introduction

A well connected transportation network ensure a faster and more reliable travel times. This is important as time spent in traffic jam resulted in wasteful expenditure on fuel, out of pocket expenses as well as time which could have been utilized in other productive activities. A high quality road network is important for high level of economic performance. It helps in sustained economic growth, increases the productivity, helps in increment in regional development and increases competitiveness. The infrastructure projects brings economic benefits in long-term by raising the productivity, innovation, lower prices, increases the income and overall creates more jobs thus bring more boom to the economy. A well-plan transportation network helps the business to expand. It allows businesses to manage their inventories and transport goods more cheaply and efficiently as well as access a variety suppliers and markets for their products making it more making it more cost-effective for manufacturers to keep productions in and out (*An Economic Analysis of Transportation Infrastructure Investment, 2014*). Thus, the priority to reduce the infrastructure bottleneck is important for any government. This requires creation of more and more road infrastructures and maintenance of the existing one. Benefit-cost analysis totals the annual user benefit derived from the road project and compares these benefits to total costs related to construction (*Evaluating Roads as Investments, The University of Kansas, 2008).*In this context a benefit-cost analysis has been carried out to find out the economic viability of road infrastructure improvement projects in the city of Chandigarh.

Study Area in Details**:** Chandigarh, the dream city of India's, was planned by the famous French architect Le Corbusier. Picturesquely located at the foothills of Shivaliks, it is known as one of the best experiments in urban planning and modern architecture in the twentieth century in India. The city assumed the unique distinction of being the capital city of both, Punjab and Haryana while it itself was declared as a Union Territory (UT) and under the direct control of the Central Government. The total area of Chandigarh is 114 sq. km.

Master Plan of Chandigarh**:** Le Corbusier conceived the master plan of Chandigarh as analogous to human body, with a clearly defined head (the Capitol Complex, Sector 1), heart (the City Centre Sector-17), lungs (the leisure valley, innumerable open spaces and sector greens), the intellect (the cultural and educational institutions), the circulatory system (the network of roads, the 7Vs) and the viscera (the Industrial Area). The concept of the city is based on four major functions: living, working, care of the body and spirit and circulation. Residential sectors constitute the living part whereas the Capitol Complex, City Centre, Educational Zone (Post Graduate Institute, Punjab Engineering College, Punjab University) and the Industrial Area constitute the working part. The Leisure Valley, Gardens, Sector Greens and Open Courtyards etc. are for the care of body and spirit. The circulation system comprises of 7 different types of roads known as 7Vs. Later on, pathways for cyclists called V8 were added to this circulation system. The Capital complex comprises three architectural masterpieces: the "Secretariat", the "High Court" and the "Legislative Assembly", separated by large piazzas. In the heart of the Capital Complex stands the giant metallic sculpture of The Open Hand, the official emblem of Chandigarh, signifying the city's credo of "open to given, open to receive". The city centre (Sector 17) is the heart of Chandigarh's activities. It comprises the Inter-State Bus Terminus, Parade Ground, District Courts, etc. on one hand, and vast business and shopping center on the other. The 4-storey concrete buildings house banks and offices above and showrooms/shops at the ground level with wide pedestrian concourses. The Neelam piazza in the center has fountains with light and water features. Proposal to set up an eleven storey building in Sector 17 is in the offing. Sector 34 is another newly developed commercial sector.

Road Infrastructure Chandigarh: One unique feature in the layout of Chandigarh is its roads, classified in accordance with their functions. An integrated system of seven roads was designed to ensure efficient traffic circulation. Corbusier referred to these as the 7'Vs - the city's vertical roads run northeast/southwest (the 'Paths'). The horizontal roads run northwest/southwest (popularly known as *Margs*). This intersects at right angles, forming a grid or network for movement. This arrangement of road-use leads to a remarkable hierarchy of movement, which also ensures that the residential areas are segregated from the noise and pollution of traffic. Each 'Sector' or the neighbored unit is quite similar to the traditional Indian joint house system known as *mohalla*. Typically, each sectors measures 800 meters by 1200 meters, covering 250 acres of area. Each sector is surrounded by V-2 or V-3 roads, with no buildings opening on to them. Access from the surrounding roads is available only at 4 controlled points, which roughly mark the middle of each side. Typically a sector is divided in four parts by a V-4 road running from east to west and a V-5 road running from north to south. These four parts are easily identifiable as A, B, C and D corresponding to North, East, South and West sides. Each Sector is meant to be self-sufficient, with shopping and community facilities within reasonable walking distance. Though educational, cultural and medical facilities are spread all over city, however, major institutions are located in Sectors 10, 11, 12, 14 and 26. The industrial area comprises 2.35 sq. km, set-aside in the Master Plan for non-polluting, light industry on the extreme southeastern side of the city near the railway line, as far away as possible from the Educational Sectors and Capitol Complex. Tree plantation and landscaping has been an integral part of the city's Master Plan.

The Union Territory of Chandigarh is well served by an excellent network of roads. The National Highways No. 21 (*Ambala-Kinnaur*) and 22 (*Chandigarh-Leh*) are the chief road arteries linking Chandigarh with the rest of the country. The total length of roads in the UT of Chandigarh is 2587 km. National Highways in the UT measure 80 km while other roads are 2507 km. Out of these PWD roads are 853.97 km, Municipal Corporation (MC) roads measured about 1580 km and rural roads accounts 73.03 km. PWD and MC together constitutes city roads.

The engineering department of UT of Chandigarh is looking after the operation and maintenance of road work, water supply, sewerage, storm water disposal system, street light, parking, and etc. of Chandigarh. For the improvement of road infrastructure and easy movement of traffic, Capital Project Division No. 2, Chandigarh intends to construct flyovers, underpasses and bridge within the city. The proposed project includes construction of the following road infrastructure.

1. Two lane ***flyover*** on Kalka-Chandigarh for access to Panchkula after Housing Board Junction,
2. Six lane high level ***bridge*** over drain (*nallah*) between sector 51 and sector 62,

3. 3 numbers two lane ***Underpasses*** for light vehicular traffic.

In this paper we have attempted to find out the economic viability of carrying out the above-mentioned road-infrastructure projects. A cost-benefit approach has been adopted here to carry out the Economic Internal Rate of Return (EIRR).

The review of literature highlights on some past studies on studying economic viability of road infrastructure projects. The next part describes the detail approach and methodology of carrying out the economic analysis. The approach is followed by costing pattern which mainly describes about the capital and maintenance costs. These costs have been derived from engineering cost estimates. Project benefits points out the benefits accrue from reduced fuel consumptions due to improvement of roads i.e. idling fuel consumption and time savings to road users due to reduction in delays. Further, the economic analysis of calculation of EIRR is followed by a sensitivity analysis and conclusion.

2.0 Review of Literature:

Every nations benefit from a well performing transportation network. It helps the business enterprises to manage their inventories and transport, access suppliers and market for their products. The consumer gets the benefit from lower priced goods, workers by better access to work place etc. Peoples and firms derive benefits from shared access of inputs and production due to an efficient transportation network (Marshal, 1890). Contemporary research reveals the high economic gain from expenditure of public capital (Aschauer, 1989). Recent research literatures point out the importance of the public investment on the basis of their contributions to economy. Further it also emphasized the importance of keeping the assets in good conditions through maintenance and repairs (Kahn and Levinson, 2011, Gramlich, 1994). A research report of Texas Transportation Institute highlights that American commuters in urban areas collectively spent 5.5 billion hours in traffic jam which means a loss of week time by an average commuter. Further these commuters stuck in traffic congestion spent 120 billion USD for purchase of extra 2.9 billion gallon of extra fuel (Schrank et. al. 2011). A well maintained roads, other driving alternatives and access to public transportation network can save the life through reduction of accidents. The road bottlenecks cause a loss of 7.8 billion USD annually for truck transportation industries by causing a loss of 243 million hours of delays in USA (White & Grenzeback, 2007). A 2005 survey report of Economic Development Research Group concluded that because of the long time shipping business group at added cost re –orient their supply chain, plan more inventories, open up more distribution centre. The construction of flyovers, bridges and underpasses is considered as an effective way of managing traffic and avoiding the traffic delays. It helps in reducing unnecessary wastage of fuel while waiting in the traffic signal (Goyal et.al., 2009). The report of John Isbell (2006) revealed that to compensate the shipping delays in USA, Nike spent an addition 4 million USD per week to carry out an extra 7 to 14 days inventory. Similarly, the report of John Bowe (2006) pointed out that the Trans Pacific Services; USA spent additional 4 million USD per annum to increase its containers and chassis by 1300. Investment in transportation not only ensures more economic activities but geographical distribution of the same. A study by Weinstein (1999) on the impact of LRT on living standard point out that public expenditure on infrastructures increases the property value thus increases the living standard of the community living in the vicinity. This was confirmed by Haugwout (2002) in his study on productivity and welfare aspects of public infrastructure investments. This was further confirmed by other researchers that property values increases multiple times when it is located near public transit system in their study in Sacramento, Chicago, San Diego and St.Louis (Landis, 1995, Gruen, 1997, Cervero et.al., 2002 and Garett, 2004). The economic impact of smart investment in infrastructure creates millions of jobs. These jobs are created across a wide variety of different industries. For example, road building not only requires construction workers, but also grading and paving equipment, gasoline or diesel to run the machines, smaller hand tools of all sorts, raw inputs of cement, gravel, and asphalt, surveyors to map the site, engineers and site managers, and even accountants to keep track of costs. This was confirmed through a study by Bureau of Labor Statistics, USA (2012). Transportation cost is a major expenditure that is accounted after expenditure on housing. Thus reduction of fuel consumption due to maintenance of roads helps the peoples to spend less money on transportation expenditure. Further improvement in transportation system reduces the cost associated with congestion and additional wear and tear caused by poor road conditions.

The deteriorated roads accelerate the depreciation of vehicles and the need for repairs because the stress on the vehicle increases in proportion to the level of roughness of the pavement surface. Further, the tire wear and fuel consumption increase as roads deteriorate since there is less efficient transfer of power to the drive train and additional friction between the road and the tires (TRIP Study 2013). Further the above-mentioned study estimates that the average motorist in the USA pays $377 each year in additional vehicle operating costs as a result of driving on roads in need of repair, which varies by major urbanized area. Vlieger et. al. (2000) pointed that the road and conditions and traffic behavior affects the fuel consumption. Construction of modern roundabouts can improve the vehicular traffic flows and will reduce the fuel consumption by cutting down the idle time at intersections (Mandavilli et. al., 2003). In order to quantify fuel consumption a study was conducted by Gandhi et. al. (1983). Latter the Automotive Research Association of India collected extensive data from city of Mumbai, Chennai, Bengaluru and Pune to develop to standardized idle fuel consumption (Badusha and Ghosh, 1999).

3.0 Objective:

The objective of the paper is to assess the economic viability of the proposed flyovers high level bridge and underpasses at following locations:

- *Construction of 3 lane dual carriageway elevated road (flyover) for housing board light point junction on Chandigarh Kalka Road,*

- *Construction of 2 lane dual carriageway high level bridge on N-Choe passing across V-3 road between Sector 51 to 62 Chandigarh (near Yadavindra Public School),*
- *Construction of 2 lane underpass for pedestrians and light vehicular traffic for joining V-5 roads between sector 9 & 17, sector 34 & 35, sector 22 &35.*

4.0 Methodology and Approach

Economic viability of the project has been assessed within the broad framework of "Cost-Benefit Analysis", generally used for appraisal of public investment projects. In economic evaluation, benefits are computed for the economy as a whole rather than for an individual entity that has made the investment. In case of financial analysis the profits become the major factor for evaluation whereas in economic analysis the benefits to the economy are the main criteria for evaluation.

The economic analysis involves comparison of project costs and benefits in economic terms under the "with" and "without" project conditions and determination of the Economic Internal Rate of Return (EIRR) of the project using discounted cash flow technique. This shows the return which the society could expect from the proposed investment during the project life, i.e. the benefit period. The feasibility of the project is determined by comparing the EIRR with the current accounting rate of return of 12%. This represents the opportunity cost of capital and is considered an appropriate minimum criterion for economic viability by both the Government of India and international funding agencies like the World Bank and the Asian Development Bank (ADB).

The main steps followed are:

i) Estimation of future traffic on the existing and proposed facilities
ii) Estimation of capital and maintenance costs (both regular and periodic) at economic prices
iii) Estimation of economic benefits
iv) Comparison of annual streams of costs with benefits and estimation of EIRR

The project is further subjected to sensitivity analysis by assessing the effects of adverse changes in the key variables on the base EIRR. This helps to gauge the economic strength of the project to withstand future risks and uncertainties.

4.1 Definition of "Without" and "With" Project Situations

4.1.1 "Without Project" Situation

(A) Without Project Situation for construction of 3 lane dual carriageway elevated road (flyover) for housing board light point junction on Chandigarh Kalka Road:

In the existing or "without project" situation, all traffic bound for Kalka, Pinjore, Shimla, Badi, and Panchkula has to pass through Housing Board Light Point in Chandigarh –Kalka Road. The traffic on this road is enormous that creates frequent traffic bottlenecks at Housing Board Light Point. This resulted in congestion and causes substantial delay to the traffic.

(B) Without Project Situation for construction of 2 lane dual carriageway high level bridge on N-Choe passing across V-3 road between Sector 51 to 62 Chandigarh (near Yadavindra Public School):

In the existing or "without project" situation, there is a missing link of road between Sector-51 and Sector 62. This missing road link is opposite Yadavindra Public School road. The N-Choe adjacent to this road lies in the Union Territory of Chandigarh. This resulted in substantial delay to the traffic between Chandigarh and Mohali.

(C) Without Project Situation for construction of 2 lane underpass for pedestrians and light vehicular traffic for joining V-5 roads between sector 9 & 17, sector 34 & 35, sector 22 &35:

In the existing or "without project" situation, there exist no underpass connecting V4/V5 roads of sector 9&17, sector 34&35, sector 22&35. As a result the pedestrian and light vehicular traffic had to travel on the main roads i.e. Madhya Marg / Himalaya Marg and move around the junctions for reaching to opposite sectors. This resulted in increased traffic jams at the junctions/light points.

4.1.2 "With Project" Situation

(A) With Project Situation for construction of 3 lane dual carriageway elevated road (flyover) for housing board light point junction on Chandigarh Kalka Road:

In order to avoid the above-mentioned bottleneck it is proposed to construct a 3 lane dual carriageway elevated road (flyover) at T Junction from Madhya Marg on Maulijagaran road to cater all the traffic from Madhya Marg to Panchakula. This will ease out the traffic congestion at Housing Board light point junction on Chandigarh Kalka Road. This is the "with project" situation.

The following sections deal with the economic evaluation of the recommended option for the proposed Flyover. The length of the main flyover is estimated as 0.412 km and the approaches are 0.305 km. The widths are 8.5 meter.

(B) With Project Situation for construction of 2 lane dual carriageway high level bridge on N-Choe passing across V-3 road between Sector 51 to 62 Chandigarh (near Yadavindra Public School):

In order to provide better connectivity between Chndigarh and Mohali, it is proposed to construct a 2 lane dual carriageway high level bridge on N-Choe passing across V-3 road between Sector 51 to 62 Chandigarh (near Yadavindra Public School). This is the "with project" situation.

The following sections deal with the economic evaluation of the recommended option for the proposed high level bridge. The length of the main bridge is estimated as 0.025 km. Here one approaches is 0.05 km and the other one 0.2 Km.

(C) *With Project Situation Situation for construction of 2 lane underpass for pedestrians and light vehicular traffic for joining V-5 roads between sector 9 & 17, sector 34 & 35, sector 22 &35:*

In order to provide smooth flow of traffic from one sector to anther sector (between sector 9 & 17, sector 34 & 35, sector 22 &35), Chandigarh administration has proposed to construct 2 lane underpass for pedestrians and light vehicular traffic for joining V-5 roads between sector 9 & 17, sector 34 & 35, sector 22 &35. This is the "with project" situation.

The following sections deal with the economic evaluation of the recommended option for the proposed underpasses. The length of the main underpass is estimated as 0.05 km. (Approximately) and approaches are 0.2 Km (approximately).

4.2 Project Cost and Scheduling

The project cost consists of two main components:

- Capital cost
- Maintenance cost

Economic analysis requires the conversion of financial costs into economic costs to take care of distortions in prices due to market imperfections. Taxes and duties are removed from financial prices as these are not real costs to the economy, but are only transfer payments.

All financial costs have been converted into economic costs by applying a Standard Conversion Factor (SCF) of 0.85, as suggested by the Ministry of Road Transport and Highways and ADB/World Bank and is generally used for economic evaluation of highway projects in India.

4.2.1 Capital Cost

The capital cost includes the cost of improvement of proposals like flyover/high level bridge/underpass, etc., widening of road work, shifting and diversion of services, cost of traffic diversion and supervision charges during construction. These are estimated in financial terms i.e. at market prices. The capital cost of all the project in financial and economic terms are summarized below in **Table 1**.

Table 1: Capital Cost of Project at 2015 Prices

(in INR Millions)

Sl. No.	Total Cost	Financial Cost	Economic Cost
1.	Construction of Flyover at (T- Junction from Madhya Marg on Maulijagaran road) Housing Board Light-point	196.99	167.44

(in INR Millions)

Sl. No.	Total Cost	Financial Cost	Economic Cost
2.	Construction of 2 lane dual carriageway high level bridge on N-Choe passing across V-3 road between Sector 51 to 62	89.19	75.81

(in INR Millions)

Sl.	Total Cost	Financial Cost	Economic

No.			Cost
3(a)	Construction of 2 lane underpass for joining V-5 roads between sector 9 & 17	56.78	48.26
3(b)	Construction of 2 lane underpass for joining V-5 roads between sector 34 & 35	55.81	47.44
3(c)	Construction of 2 lane underpass for joining V-5 roads between sector 22 &35	50.06	42.55

4.2.2 Maintenance Cost

Maintenance costs are recurring costs, comprising routine and periodic maintenance components. The routine maintenance involves day-to-day repairs and maintenance of flyover/ high level bridge/underpass etc.

In addition to the capital cost, the routine maintenance cost would start incurring from the first year of starting of the project (in this case 2015 is the starting year of the project). The maintenance cost is calculated @ 0.50% of the total cost per annum for the period 2015 to 2016, @ 0.20% for the period 2017-2025. For 2026-2035, again this cost will increase and is calculated @ 0.5%, and 1.0% thereafter.

The cost of annual routine maintenance of flyover, at the above-mentioned rate, works out to be INR 0.98 million per annum from 2015 to 2016, INR 0.39 million for the period 2017-2025, INR 0.98 million during 2026-2035 and INR 1.97 million per annum during 2036-2047 at the market price.

Similarly, the cost of annual routine maintenance of high level bridge, at the above-mentioned rate, works out to be INR 0.45 million per annum from 2015 to 2016, INR 0.18 million for the period 2017-2025, INR 0.45 million during 2026-2035 and INR 0.89 million per annum during 2036-2047 at the market price.

The cost of annual routine maintenance cost of 2 lane underpass for joining V-5 roads between sector 9 & 17, at the above-mentioned rate, works out to be INR 0.28 million per annum from 2015 to 2016, INR 0.11 million for the period 2017-2025, INR 0.28 million during 2026-2035 and INR 0.57 million per annum during 2036-2047 at the market price.

The cost of annual routine maintenance cost of 2 lane underpass for joining V-5 roads between sector 34 & 35, at the above-mentioned rate, works out to be INR 0.28 million per annum from 2015 to 2016, INR 0.11 million for the period 2017-2025, INR 0.28 million during 2026-2035 and INR 0.56 million per annum during 2036-2047 at the market price.

Finally, the cost of annual routine maintenance cost of 2 lane underpass for joining V-5 roads between sector 22 & 35, at the above-mentioned rate, works out to be INR 0.25 million per annum from 2015 to 2016, INR 0.10 million for the period 2017-2025, INR 0.25 million during 2026-2035 and INR 0.50 million per annum during 2036-2047 at the market price.

All maintenance costs are converted into economic costs by applying a factor of 0.85. The maintenance costs in economic and financial terms are presented in **Table 2**.

Table 2: Maintenance Costs

(INR Million)

Sl. No.	Routine Maintenance cost per year for Construction of Flyover at (T Junction from Madhya Marg on Maulijagaran road) Housing Board Light-point	Total	
		Financial	Economic
1.	2015 & 2016	0.98	0.84
2.	2017-2025	0.39	0.33
3.	2026-2035	0.98	0.84
4.	2036-2047	1.97	1.67

(INR Million)

Sl. No.	Routine Maintenance cost per year for construction of 2 lane dual carriageway high level bridge on N-Choe passing across V-3 road between Sector 51 to 62	Total	
		Financial	Economic
1.	2015 & 2016	0.45	0.38
2.	2017-2025	0.18	0.15
3.	2026-2035	0.45	0.38
4.	2036-2047	0.89	0.76

(INR Million)

Sl. No.	Routine Maintenance cost per year for 2 lane underpass for joining V-5 roads between sector 9 & 17	Total	
		Financial	Economic
1.	2015 & 2016	0.28	0.24
2.	2017-2025	0.11	0.10
3.	2026-2035	0.28	0.24
4.	2036-2047	0.57	0.48

(INR Million)

Sl. No.	Routine Maintenance cost per year for 2 lane underpass for joining V-5 roads between sector 34 & 35	Total	
		Financial	Economic
1.	2015 & 2016	0.28	0.24
2.	2017-2025	0.11	0.09
3.	2026-2035	0.28	0.24
4.	2036-2047	0.56	0.47

(INR Million)

Sl. No.	Routine Maintenance cost per year for 2 lane underpass for joining V-5 roads between sector 22 & 35	Total	
		Financial	Economic
1.	2015 & 2016	0.25	0.21
2.	2017-2025	0.10	0.09
3.	2026-2035	0.25	0.21
4.	2036-2047	0.50	0.43

4.3 Infrastructure Project Benefits

In the urban context, improvement scheme in the form of flyover/interchange/high level bridge/underpass to allow traffic movements to move without stopping at signal would result in the following benefits to the user:

- Reduced fuel consumption due to reduction in stopped vehicular delays (idling fuel consumption)
- Saving in time due to elimination and reduction of delays, thus improved travel speeds
- Saving in fuels due to improved travel speeds

All the above benefits from the project will accrue mainly to the traffic, which will use the proposed flyover/high level bridge/underpass. The traffic remaining on the existing road would also benefit since they would enjoy reduced congestion after the construction of the flyover.

The traffic considered for economic evaluation is the projected traffic in the "without" and "with" project situations.

Benefits from the proposed flyover will be both direct and indirect. The present analysis, however, is restricted to quantification of direct benefits in terms of savings in idling fuel consumption and savings in time due to higher speeds.

The indirect benefits like reduction in accidents and improved environmental conditions are difficult to quantify and hence are not included in the viability analysis.

4.3.1 Idling Fuel Consumption

At signalized intersections, when the signal show 'red' phase, vehicles have to stop at the intersections till the 'green' phase is displayed. During such stoppages, the drivers have a tendency to keep the engine ignition –ON, which results in extra fuel consumption called 'Idling Fuel Consumption'. Congested intersections when provided with flyover/underpasses/bridge would result in elimination of stoppages for the peak directional traffic using grade separators. In addition, the signal for at-grade traffic can be redesigned for the left over traffic, which would further reduce the average vehicular delays at intersections, thus reducing idling fuel consumption.

The idling fuel efficiency for various vehicle types used for calculation of benefits is given in **Table 3**. These rates are based on various studies in India, notably studies of Central Road Research Institute (CRRI), New Delhi.

Table 3: Average Fuel Economy and Fuel Consumption During Idling for Different Category of Vehicles

Vehicle Type	*Average Fuel Economy (km/l)*	*Fuel consumption during Idling (l/h)*
2W	45	0.34
3W	25	0.42
4W	16	0.48
LCVs	10	0.69

Source: CRRI Study Report

The vehicular delays have been calculated for the off peak and peak hours. Thus, for each junctions/missing link, the delays and traffic in peak and off-peak periods for the without and with project situations are used along with unit idling fuel consumption to obtain the fuel saving as a result of reduced delays. The fuel consumption during running and the forced idling of vehicles on the main road and flyover, missing road link has been estimated taking into account the average fuel economy and fuel consumption for each of the types of vehicles. The annual mode-wise idling consumption costs are calculated as:

$$IC_{op} = \frac{T_{op} \times d_{op} \times FC \times 365 \times C_f}{3600}$$

$$IC_{pk} = \frac{T_{pk} \times d_{pk} \times FC \times 365 \times C_f}{3600}$$

IC_{op}/ IC_{pk} = Annual idling fuel consumption costs in off-peak and peak period

T_{op}/ T_{pk} =Average traffic in off-peak and peak periods
d_{op}/ d_{pk} =Average delay (sec) in off-peak and peak periods
FC =Idling fuel efficiency (liters/hour)
C_f =Cost of Fuel (INR / liter)

The mode-wise idling costs for peak and off-peak periods are added to obtain the annual idling consumption costs for 'without' and 'with' project situation separately. The benefits are estimated as a difference of costs in the 'without' and 'with' conditions.

4.3.2 Time Savings

In order to work out time saving, the speeds for different vehicles in "without" and "with" project situation on different sections of the existing road and proposed flyover/high level bridge/underpass have been estimated. The Consultants have adopted the values of time (VOT) classified by mode of travel, given in Updation of Road Users Costs Data 2001 (RUC), of Ministry of Transport and Highways, which is modified with 2015 WPI. The weighted average delay costs adopted for estimation of benefits under the proposed flyover/high level bridge/underpasses are calculated taking into account the VOT.

The estimation of Annual Time Delay costs for each turning movements in the off-peak and peak periods can be calculated by using the equation given below:

$$TD_{op} = \frac{T_{op} \times d_{op} \times DC \times 365}{3600}$$

$$TD_{pk} = \frac{T_{pk} \times d_{pk} \times DC \times 365}{3600}$$

TD_{op}/ TD_{pk}= Annual time delay in off peak and peak periods
T_{op}/ T_{pk} =Average traffic in off-peak and peak periods
d_{op}/ d_{pk} =Average delay (sec) in off-peak and peak periods
DC =mode-wise average delay cost (INR/hour) from Table 3

The mode-wise time-delay costs for peak and off-peak periods from above - equations are added to obtain the annual time delay costs for 'without' and 'with' project conditions separately. The benefits are then estimated as a difference of costs in the 'without' and 'with' conditions.

5.0 Conclusion:

5.1 Economic Internal Rate of Return (EIRR)

The cost-benefit analysis would signify whether adequate returns in terms of benefit results from making a capital investment. The appraisal is done based on the costs and benefit that would be incurred over the analysis period if no investment is made and by comparing the costs and benefits arising as a result of making an investment. The annual cost and benefit streams are used to derive the net cash flow for the project. The analysis considers 32 years of benefit period from the opening year i.e. 2015. For the present purpose, the viability has been established by assessing the EIRR and Net Present Value (NPV) using the discounted cash-flow technique for the flyover/bridge/underpass project respectively. The EIRR has been compared with the accounting rate of return of 12 percent. The result is presented in **Table 4.**

Table 4: Results of Economic Analysis

Sl. No.	*Flyover*	*EIRR (%)*
1	Construction of Flyover at (T Junction from Madhya Marg on Maulijagaran road) Housing Board Light-point	15.57

Sl. No.	*High-level bridge*	*EIRR (%)*
2	Construction of 2 lane dual carriageway high level bridge on N-Choe passing across V-3 road between Sector 51 to 62	21.05

Sl. No.	*Underpass between Sect. 9 & 17*	*EIRR (%)*
3(a)	Construction of 2 lane underpass for joining V-5 roads between sector 9 & 17	15.05

Sl. No.	*Underpass between Sect. 34 & 35*	*EIRR (%)*
3(b)	Construction of 2 lane underpass for joining V-5 roads between sector 34 & 35	14.14

Sl. No.	*Underpass between Sect. 22 & 35*	*EIRR (%)*
3(c)	Construction of 2 lane underpass for joining V-5 roads between sector 22 & 35	14.16

The rate of return considered desirable for transport infrastructure projects in India is 12 percent. As in all these scenario EIRR is higher than 12%, the proposed investment projects are economically viable.

5.1 Sensitivity Analysis

The robustness of the project's viability is further demonstrated by the sensitivity analysis. Because of the uncertainties surrounding many of the variables like traffic forecasts, cost changes due to detailed designing, etc., a sensitivity analysis was carried out to test the economic strength of the project. The variations in the following parameters have been examined, considering them to be on the conservative side:

i) Increase in cost by 15 percent
ii) Decrease in benefits by 15 percent
iii) Increase in cost by 15 percent and decrease in benefits by 15 percent

The results of the sensitivity analysis are presented in **Table 5.**

Table 5: Sensitivity Analysis Results

Construction of Flyover at (T Junction from Madhya Marg on Maulijagaran road) Housing Board Light point

Sl. No.	*Case*	*EIRR (%)*
1	Base Case	15.57
(i)	Increase in Cost by 15 percent	14.56
(ii)	Decrease in benefits by 15 percent	14.38
(iii)	Increase in cost by 15 percent and decrease in benefits by 15 percent	13.44

Construction of 2 lane dual carriageway high level bridge on N-Choe passing across V-3 road between Sector 51 to 62

Sl. No.	*Case*	*EIRR (%)*
2	Base Case	21.05
(i)	Increase in Cost by 15 percent	19.71
(ii)	Decrease in benefits by 15 percent	19.48
(iii)	Increase in cost by 15 percent and decrease in benefits by 15 percent	18.25

Construction of 2 lane underpass for joining V-5 roads between sector 9 & 17

Sl. No.	*Case*	*EIRR (%)*
3	Base Case	15.05
(i)	Increase in Cost by 15 percent	14.09
(ii)	Decrease in benefits by 15 percent	13.92
(iii)	Increase in cost by 15 percent and decrease in benefits by 15 percent	13.01

Construction of 2 lane underpass for joining V-5 roads between sector 34 & 35

Sl. No.	*Case*	*EIRR (%)*
4	Base Case	14.14
(i)	Increase in Cost by 15 percent	13.22
(ii)	Decrease in benefits by 15 percent	13.06
(iii)	Increase in cost by 15 percent and decrease in benefits by 15 percent	12.18

Construction of 2 lane underpass for joining V-5 roads between sector 22 & 35

Sl. No.	*Case*	*EIRR (%)*
5	Base Case	14.16
(i)	Increase in Cost by 15 percent	13.24

(ii)	Decrease in benefits by 15 percent	13.08
(iii)	Increase in cost by 15 percent and decrease in benefits by 15 percent	12.21

It can be seen from the above, that even in the worst case of increase in cost and decrease in benefits all the projects remains economically viable.

REFERENCES

Alfred Marshall, *Principles of Economics*, London: Macmillan and Co., Ltd: 1890.

An Economic Analysis of Transportation Infrastructure Investment, National Economic Council and The President's Council of Economic Advisers, The White House, Washington, July, 2014.

Andrew F. Haughwout, *Public Infrastructure Investments, Productivity and Welfare in Fixed Geographic Areas*, Journal of Public Economics (March 2002) 83(3): 405-428.

Badusha, A. A., & Ghosh, B., Driving Cycle for Buses in Delhi City. Society of Automobile Engineers, Inc., SAE Technical paper series No. 990036, 1999, pp. 369–376.

Bowe, John, *The High Cost of Congestion,* Presentation to the TRB Freight Roundtable, October 24, 2006, www.trb.org/conferences/FDM/Bowe.pdf.

Central Road Research Institute (CRRI), New Delhi, Study Report, www.pcra/English/transport.

Cervero, R. et al., *Land Value Impacts of Rail Transit Services in San Diego County*, Urban Land Institute, 2002.

David Alan Aschauer, *Is Public Expenditure Productive?* Journal of Monetary Economics, 23(2) (March 1989): 177–200.

David Schrank, Bill Eisele, and Tim Lomax, *Texas Transportation Institute's 2012 Urban Mobility Report*, December 2012.

Economic Development Research Group, *The Cost of Congestion to the Economy of the Portland Region*, 2005.

http://www.portofportland.com/PDFPOP/Trade_Trans_Studies_CoCReport1128Final.pdf.

Edward M. Gramlich, *Infrastructure Investment: A Review Essay*, Journal of Economic Literature, 32(3) (September 1994): 1176–1196.

Evaluating Roads as Investments, *A Primer on Benefit-Cost and Economic-Impact Analysis*, The Center for Applied Economics, The University of Kansas, 2008.

Gandhi, K. K., Zvonow, V. A., et al., *Development of a Driving Cycle for fuel Economy in a Developing country*. Transportation Research Part A, 17(1), 1–11, 1983.

Garrett, T., *Light Rail Transit in America: Policy Issues and Prospects for Economic Development*, Federal Reserve Bank of St. Louis, 2004.

Goyal, S.K., Goel, S., and Tamahne, S. M., *Assessment of Environmental Benefits of Flyover Construction over Signalized Junctions: A Case Study*, Environ Monit Assess, 2009, 148:397-408.

Gruen, A., *The Effect of CTA and METRA Stations on Residential Property Values*. Regional Transportation Authority, 1997.

Isbell, John, *Maritime and Infrastructure Impact on Nike's Inbound Delivery Supply Chain*, TRB Freight Roundtable, 2006.

http://www.trb.org/conferences/FDM/Isbell.pdf.

Karen White and Lance R. Grenzeback, *Understanding Freight Bottlenecks," Public Roads 70(5) (March/April 2007).*

Available at: https://www.fhwa.dot.gov/publications/publicroads/07mar/05.cfm.

Landis, J. et al., *Rail Transit Investments, Real Estate Values, and Land Use Change: A Comparative Analysis of Five California Rail Systems*, Institute of Urban and Regional Development, UC Berkeley, 1995.

Mandavilli, S., Russell, E. R., & Margaret, J. R., *Impact of Modern Roundabouts on Eehicular emissions*, 2003.

www.ctre.iastate.edu/PUBS/midcon2003/MandavilliRoundabouts.pdf.

Matthew Kahn and David Levinson, *Fix It First, Expand It Second, Reward It Third: A New Strategy for America's Highways*, Hamilton Project, 2011.

TRIP, *Bumpy Roads Ahead: America's Roughest Rides and Strategies to Make our Roads Smoother*, 2013.

Vlieger, I. De, Keukeleere, D. De, & Kretzschmar, J. G., *Environmental Effects of Driving Behaviour and Congestion Related to Passenger Cars,* Atmospheric Environment, (2000),34, 4649–4655.

Weinstein, B., et. al., *The Initial Economic Impacts of the DART LRT System*, Center for Economic Development and Research, University of North Texas, 1999.