Shaping Smart City transportation with Traffic Congestion Solutions: Bhubaneswar, Odisha

Abstract:

Transportation and connectivity are of the most domineering aspects of developing cities and is necessary for ensuring the growth of urban areas. The perplexing, perpetual and complex concerns in present cosmopolis are sluggish traffic movement and jamming. In India, due to rapid increase in population along with urbanization and improved living condition, the vehicular population have increased massively. Traffic congestions has become a major problem at intersections. The main objective of this project is to analyse traffic problems at a suitable intersection and suggesting an alternate solution. In this study, we have taken two main intersections, one at Kalinga Hospital Square junction and another at Damana Square junction. After analysing and comparing peak values of two intersections, junction with highest peak value is of first choice. According to IRC: SP: 90-2010, manual for grade separators and elevated structures the maximum volume a rotary can handle is specified as 5000pcu/hr and an elevated structure could be provided beyond this limit. A simple grade separator, that is, a flyover provided at this intersection to segregate the high volume of traffic. With the flyover at the intersection, major proportion of the traffic volume is side tracked to the fly over bridges, and abridges the delay of vehicles. Thus, the same volume of traffic bifurcate to move at two different levels and leaves no chance for any accident. On implementation of the project, along with smart traffic and the intelligent transportation system, the present and future demands of the traffic flow along the route will be satisfied without any distraction in traffic management.

Keywords: Bhubaneswar, Grade-separator, fly over, Smart Transport; Urbanization, Traffic Jam

1.1 INTRODUCTION

Rising traffic congestion is an inevitable chaos in fast growing traffic in metropolitan cities globally. Wild rise in human growth has resulted in an extensive increase in vehicular movement. People in urbans have higher socio-economic status than before. The paradigm shift in pavements, mode of transport, and traffic control has transformed melancholic and risk less movement to fast, expensive self-owned vehicles in use. The causes of traffic congestions include improper planning of roads considering future capacity. Therefore, traffic analysis is essential for improvement of existing facilities and future needs of the road.

The construction of Flyovers at intersections are poised to be traffic congestion solutions with smart traffic management when the majority of the traffic travels between the two fringe points between NH-16 (Jaydev Vihar to KIIT square) **(Fig 1 (a) and Fig 1(b).** The new access-controlled fly over add two extra lanes for uninterrupted traffic that enhances the pavement capacity by depleting the travel time so that more traffic is accommodated. The significant enhancement of traffic volume with surged pavement capacity eliminates the chances of congestion, accidents and conflicts.

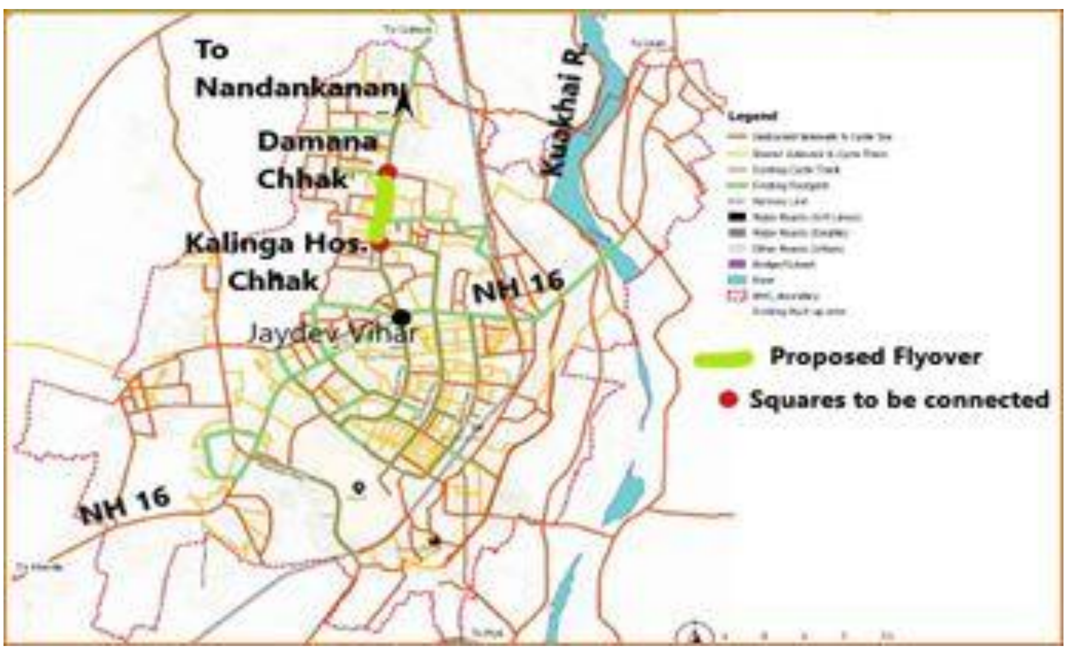


Fig 2: Proposed flyover from Kalinga Hospital and Damana; BBSR (Source: BMC map modified)

Bhubaneswar was a temple city in 1948 housed in area 25.9km^2 transformed to new capital and presently one among the flourishing smart city in 2022 comprising of area 186km$^{2.}$ (BMC has 147km2). Staring from a population of 16k in 1950 architecturally planned for accommodating 20k more officials. The healthy climate, availability of more land, the township flourished, expanded, and accommodating today in 2022 projected for 1200k citizens. Parallel to the urban agglomeration, the city has planned for easy and wider road infrastructure to accommodate expanding traffic. The transport utilities like roads, railways and airport covers an area of 10.93 km^2 inclusive institutional utilities. With expansion of the city the transport network, particularly the surface connectivity given more weightage (**Fig 2).**

Air pollution, noise, human health hazards, environmental degradation and accidents/trauma are the symptoms of traffic congestion metropolis (Bhuyan et al., 2013[1], Gupta et al., 2019[2], Montanaro et al., 2022[3]). It is alarming that The Odisha state Crime Branch, and the transport department reported that deaths due to road accidents were 3931 in 2014 in 5111km of roads, which has been rose to 4738 during 2020. The accident death/100 accidents was 48.2% above the nation's average 36.65%. https://www.ceicdata.com/ en/india/ roads-and-highways-statistics-length-of-roads-by-structure. In this paper, traffic congestions evaluated at selected intersections and data regarding the traffic volume collected manually by insitu field observations. On analysis, the observed data, numerous ameliorative measures basing on projecting focus on junction upgrading and substitute maneuver plans. Despite of the huge investment on the renovation, congestions abridged to certain extent by providing signalized traffic junctions, providing roundabouts, flyovers, interchanges, etc, (Shradhesh et al., 2020[4]).

1.2 Review of literature:

In developing countries, traffic mismanagement and surged ply of motorized vehicles have enhanced frequency and vivacity of accidents causing, health concerns, trauma, deaths both human and animals, the major anthropogenic disaster at present (Gopal Krishnan 2012[5], Goetz et al., 2019[6], Droj et al., 2022[7]). Traffic jamming instills sluggish speeds, prolonged journey spell, cropping transportation volume and making traffics queueing on roads during peak., **(Muneera et al., 2020[8]).** The road traffic accidents (RTA) have posed major public health and environmental concerns in developing countries (**Agrawal et al., 2011[9]**). The surge in escalation in motorized vehicles with rising demography, there is adequate expansion of the road and highway networks which has led to the challenges of adverse factors, such as the increase in road accidents, noise and environmental pollution in India **(Jha et al., 2003[10] Ruikar 2013[11], Saberi et al., 2020[12])**. RTA's increases in winter months particularly in daytime (Office hours) **Shrama et al., 2021**[13]**.** City infrastructural expansions like metro rails fly overs, lane augmentations, improvement of old existing roundabouts blocking the roads and generating traffic jams (Solanki et al., 2016[14]),

Policy implementation to reduce traffic congestion in Indian city roads are common. The growth of city infrastructures in transportation and drainage sectors making the flow to be hindered for months together is the main concern for normal movement within the cosmopolis (**Verma et al., 2021[15], Bokaba et al, 2022[16]).** In Indian context , road congestion arises from reasons, like traffic signals, weather, drainage congestion, defective/inefficient traffic management, climate driven, excess demands, working zones, special occasions like social and recreational events needs to be planned efficiently, (**Falcocchio, 2015**[17]**, Arfin et al., 2020**[18]) .

In India, 100 cities smart cities have developed according to government initiation, planning. The present city, the Bhubaneswar, the capital city of Odisha, have transportation as the key focussed area, **Saberi et al., 2020**[12]**.** Various strategies those can ameliorate traffic congestion in future smart cities are IOT (Internet of things), ITU –T (International Telecommunication Union – Telecommunication), ICT (information and communication technologies), and many other tools. Replacements and renovations of old squares by roundabouts or Stack Type Traffic Interchanges planned to address the traffic congestion (**Sahoo et al., 2020**[19]**, Dash et al., 2021**[20]). Electrical vehicles are best gadgets for saving CO_2 in the urban atmosphere and SPV are best solutions for smart transportation (Rao et al., 2022[21]).

Present paper investigates the status, expansions, and emergent progresses in carriage and transport sector. Study of the innovative spreads in urban smart transport system that shall shape the living standard and lively hood qualities of passenger/goods without encountering inconveniences in selected 100 smart cities of India, **(Mishra et al., 2019**[22]**).**

1.3 METHODS AND METHODOLOGY:

Traffic jam in the Jaydev Vihar and Nandankanan road (KIIT square) is one among the present major issues in transportation sector of Bhubaneswar city in spite of regular expansion of the said road by government line departments. The expanded the road network cannot cope with the parallel increase in traffic volume particularly during peak hours. The critical problem occur during at peak hour’s traffic jam of the day. The possible solutions are drawn and smart transport tools explored. The methodology is in Fig-3.

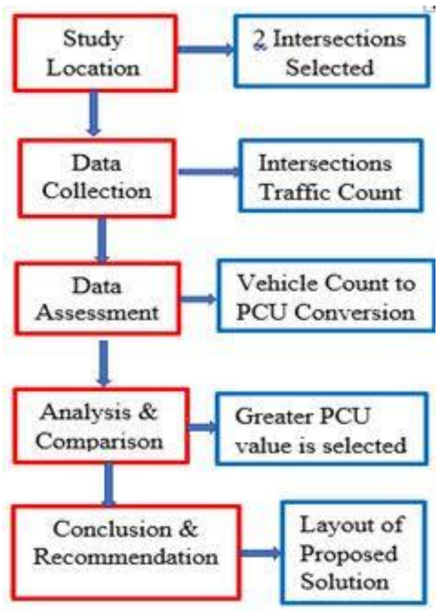


Fig 3: Methodology for proposed solution against traffic congestion in Kalinga Hosp. to Damana road

2.0 RESEARCH FRAMEWORK

The methodology consists of five steps, from selecting the intersection to providing layout of the alternative solution. After choosing the right intersection based on the analysis on the tabulated data, field measurements taken for the same intersection. Then an alternative solution suggested for reducing the traffic congestion.

3.1 **Data collection method**

There are mainly two categories in traffic counting; they are manual counts and automatic counts. In this quest, the methods are either manual counting or implemented by use of tally marks. The primary data obtained from the inventories later organized to analysis and inherit inferences. The traffic on each arm counted and recorded separately for each movement. The other method is automatic counting method, which involves various types of instruments; having their own pros and cons. The extensively used gadgets are tubes (pneumatic), inductive loops, sensors (weigh-in-motion), micro-millimetre and video camera. Here the method adopted is manual counting of different category of vehicles, since it is a direct and easy method involving no expensive equipment (**Fig 4(a); Fig 4(b)**).

Fig 4(a) : Kalinga Hospital Square (Intersecting: Four major 4-lane road i.e. Towards Jaydev Vihar, Nandankanan, Acharya Vihar and Rail Vihar)

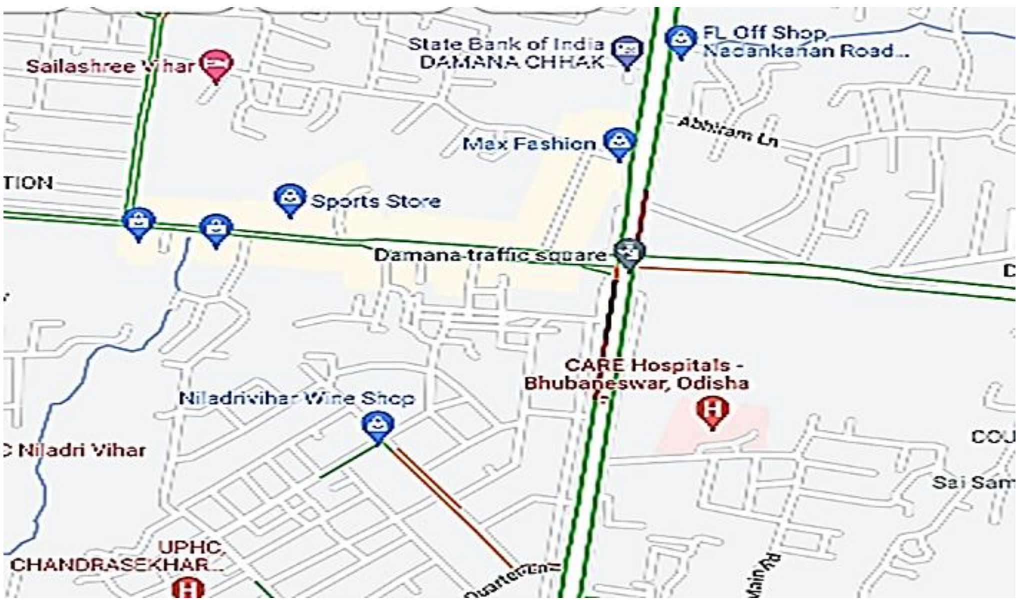


Fig 4(b) : Damana Square, Four major 4-lane road i.e. (Jaydev Vihar, Nandankanan, Sailashree Vihar/DAV School & Mancheswar Area)

3.0 DATA COLLECTION AND ANALYSIS

3.2 Estimation of PCU

Passenger Car Unit (PCU) defined, as the weightage feature agreed with the traffic volume. Some specific vehicles are susceptible to upset to an extent, to increase in its proportion of total volume of traffic. In view of these factors, the PCU conversion factor for each category of vehicles have, recommendations are IRC 106-1990[II] (**Fig 5(a) & Fig 5(b)).** Accordingly, each category of vehicle has to give proper weightage with their respective conversion factor to express the capacity of city roads in terms of a common unit of specific vehicle category to handle the mixed traffic situation. PCU is an approach used to convert the heterogeneous traffic volume to its equivalent homogeneous. Use of appropriate PCU value for distinct vehicle categories, which lead to correct measure of homogeneous traffic volume in the mixed traffic situation, which holds significance in providing the desired level of service. IRC 106-1990[II] provides the PCU factors for different categories of vehicles.

The equivalent PCUs of different vehicular categories do not remain constant under all circumstances. In urban state of affairs, various speed of different classes of vehicle is generally low. The PCU factors are mainly function of the physical dimensions of various vehicles. One car considered as a single unit, cycle or two wheelers considered as half or three-fourth of a car unit depending upon the percentage. Bus, truck causes a lot of inconvenience because of its large size. The higher order wheeled vehicles have values considered 2.2 or 3.7 according to their total percentage (As per IRC-106-1990-Table-1). In addition, the PCU of a particular vehicle type has effect by a certain extent to increase in its proportion in total traffic. Considering all these factors, the PCU conversion factor for each category of vehicles recommended is to be adhered to the stipulations made prescribed in IRC: 106-1990[III] table 1. Accordingly, each category of vehicle on multiplication with their respective conversion factor and denotes the capacity of urban roads in terms of a common unit **Table 2 (a) and Table 2(b).**

Table-2(a): Traffic survey results at Kalinga Hospital square signal (Date of survey 20.12.2021)

Name of Arm	Total Vehicles	Total Vehicles in PCU	Hourly Volume	Hourly Volume in PCU
9.00AM -10.00AM				
Jaydev Vihar-Rail Vihar	595	998		
Jaydev Vihar-Nandankanan	1878	2373		
Jaydev Vihar-Acharya Vihar	1528	2158	4001	5529
6.00PM-7.00PM				
Jaydev Vihar-Rail Vihar	1095	1552		
Jaydev Vihar-Nandankanan	1721	2285		
Jaydev Vihar-Acharya Vihar	1625	2278	4441	6115

Table-2(b): Traffic survey results at Damana square signal (Date of survey 21.12.2021)

Name of Arm	Total Vehicles	Total Vehicles in PCU	Hourly Volume	Hourly Volume in PCU
9.00AM -10.00AM				
Jaydev Vihar-Sailashree Vihar/DAV School	590	995		
Jaydev Vihar-Nandankanan	1875	2370		
Jaydev Vihar-Mancheswar	1525	2155	4000	5525
6.00PM-7.00PM				
Jaydev Vihar-Sailashree	1092	1550		

Name of Arm	Total Vehicles	Total Vehicles in PCU	Hourly Volume	Hourly Volume in PCU
Vihar/DAV School				
Jaydev Vihar-Nandankanan	1720	2280		
Jaydev Vihar-Mancheswar	1623	2275	4441	6110

3.2.1 LEVEL OF SERVICE (LOS) ESTIMATION

LOS (PCU/ Design service) is the qualitative measure that describe operational settings of roadway, and the awareness of drivers and passengers. Six levels of services designated by IRC 106-1990[II0 from A to F. **LOS-A:** the condition of free flow with average travel quickness. The level of comfort (values 0.3-0.39) and conveniences delivered to the road users are excellent. **LOS-B**: Represents a zone of stable flow where drivers have the freedom to select their desired speed. Level of comfort and convenience provided is less than the Level of Service A and ranges from 0.4 to 0.49. **LOS-C:** The general level of comfort and convenience declines at this level. It ranges from 0.5 to0.59. **LOS - D:** Represents a limit of stable flow, where conditions are approaching close to an unstable flow. Slight increase in traffic flow can cause operational problems at this level and lies from 0.6 to 0.69. **LOS - E:** Represents operating conditions when traffic volumes are at or close to their capacity level. **LOS - F**: Represents a zone of forced or breakdown flow (**Table 3**),.https://transportgeography.org/contents/methods/transport-technical-economic-performance-indicators/levels-of-service-road-transportation/.

Table 3: Operational conditions of traffic stream on the proposed study area

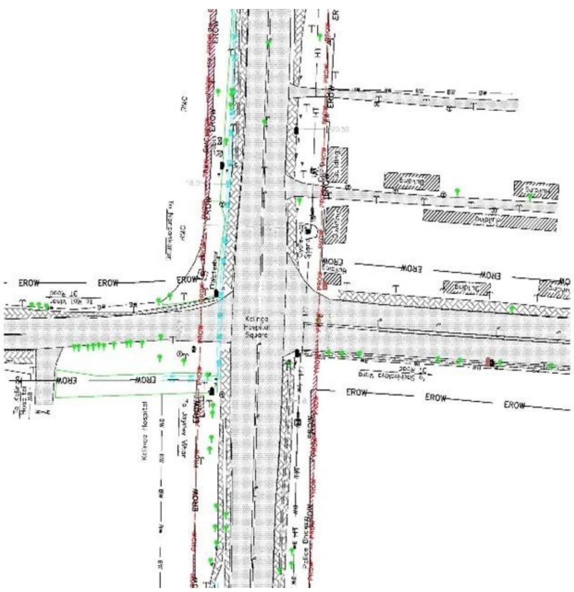
Study Area	Name of Arm	PCU/hr	Design Service Vol.	Ratio	LOS
Kalinga Hospital Square	Jaydev Vihar-Rail Vihar	2285	3600	0.63	D
	Jaydev Vihar-Nandankanan	2278	3600	0.63	D
	Jaydev Vihar-Acharya Vihar	1552	3600	0.43	B
Damana Square	Jaydev Vihar-Sailashree Vihar/DAV School	1280	3600	0.35	A
	Jaydev Vihar-Nandankanan	1011	3600	0.30	A
	Jaydev Vihar-Mancheswar	938	3600	0.30	A

NB: Design service volume IRC 106 -1990 (Table II); (For Vehicle Capacity Ratio= (PCU/Design Service Volume); For LOS=As per HCM

3.3 FINALIZATION OF AN INTERSECTION

The traffic flow over a road are variable throughout, during day/night or weekly or seasonally and also varies geospatially. The peak hour is the critical period of operations and warrants high capacity requirements for a given location. On comparing the Traffic volume count data's and also the tabulated Level of Service of the two intersections (Kalinga Hospital Square signal, and Damana Square signal), it is clear that both are the congested junction. The maximum traffic volume obtained for the Kalinga Hospital Square and Damana Square signal, which is about 6115 pcu/hr. The peak hour of this signal junction found to be 6.00 to 7.00 pm. During peak hours, the vehicles experience slower speeds, longer trip times and increased vehicular queuing at the signal. Due to the high density, the drivers could not have freedom to speed and maneuvers within the stream of congested traffic. The level of comfort and convenience become poor at this intersection (Fig 4-1(a) and Fig 1(b).

Fig 5 (a): Insitu Field fabric Kalinga Hospital Sq. Fig 5 (b) Insitu Field fabric Damana Chhak Sq**.**



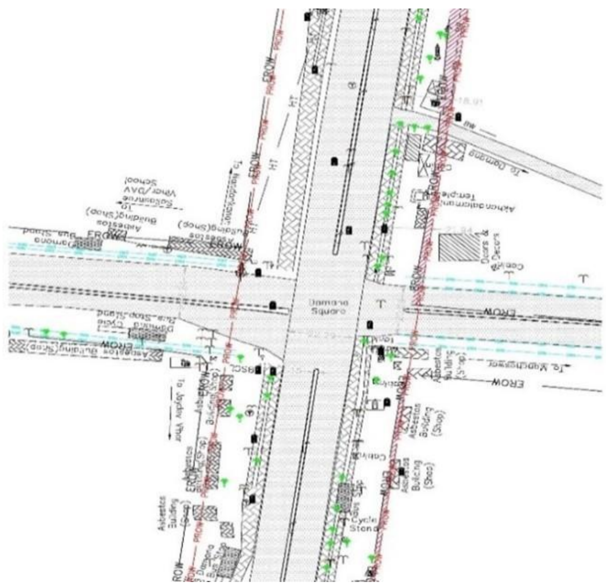


Fig 5 (a-1): Field Size of Kalinga Hosp, Sq, and Signal: Signal Fig 5 (b-1): Field size of Damana Square

4.1: FLY OVER PROPOSED**:**

After analysing and comparing peak values of two intersections the Kalinga Hospital Square signal junction and Damana Square with a highest peak value of 6114 pcu /hr selected. The capacity calculations made from observational field data reveals that intersection would fail to cater to the future traffic demands. IRC: 65-2017[V0], Guidelines for planning and design of roundabouts, specifies the traffic volume a roundabout can handle efficiently is 3000 pcu/hr. According to IRC: SP: 90-2010[I], Manual for grade separators and elevated structures the maximum volume a rotary can handle is specified as 5000 pcu/hr and an elevated structure could be provided beyond this limit. An interchange recommended only when the traffic volume is above 10,000 pcu/hr. A simple grade separator, that is, a flyover at this intersection would be the most feasible way to segregate the high volume of traffic.

Keeping pace with the increasing traffic on the road creates limited space left in the both dimensions. The option left, is to take the advantage of third dimension i.e. flyover or 3-T stacks construction. Flyovers are overpass or high-level road bridge that crosses/overpass a thoroughfare interchange or intersection. It is a grade separator built over a traffic intersection is there to allow people to divert to fly over the movement. With the flyover bridge at the intersection, a major proportion of the traffic volume diverted to the bridges, and time delay can reduce over the same period. In case of a Simple flyover, the main road used for fast traffic need to pass by a high level by a bridge, providing ramps on both the approaches and slow traffic made to pass underneath. Thus, the traffic pass at two different levels and leaves no chance for an accident. It needs large area of land, where the conflicting stream of traffic avoided, and allow traffic normal flow.

Roundabouts found to be a suitable option to manage the traffic flow under the flyover. Roundabouts are a type of circular intersection or junction in which road traffic flows continuously around the central island. The vehicles entering the roundabout gently forced to move in a clockwise direction. These are efficient intersection design over signalized intersections depending upon the traffic and site data. The need for a fly over but not a roundabout at the proposed stretch is because:

- Fly over shall eliminates the stopping of vehicles while crossing the roads. So shall ensure safety and risk reduction of accidents. Speed limits for grade-separated roads as high, high speeds can negotiate at intersections, which shall save of travel time.
- Flyovers shall save time of plying and reduce congestion in crowdie road during peak hours as Damana to Kalinga Hospital shall be future have dense markets/shopping areas. The flyover proposed shall bifurcate the dense traffic on the pathway.
- Increased capacity of arterial through traffic shall be the min benefit of the flyover. The value-added arterial flow shall permit more green time to the cross-street traffic, resulting reduced travel time for all remaining at-grade traffic.
- Grade separator delivers maximum facility to the crossing traffic and shall avoid the accident
- Shall diminish much land acquisition if tried with a round about
- Less infrastructural destruction to existing buildings and other utilities
- Shall increase parking capacity
- Shall reduce the Travel time
- Shall add to smart city transport necessities and shall promote the view.

4.1: 2D LAYOUT

2D layout of the flyover plotted in AutoCAD considering the existing measurements. The median of existing and the proposed layout is kept same and lanes offsite from median to both the sides **(Fig 6).**

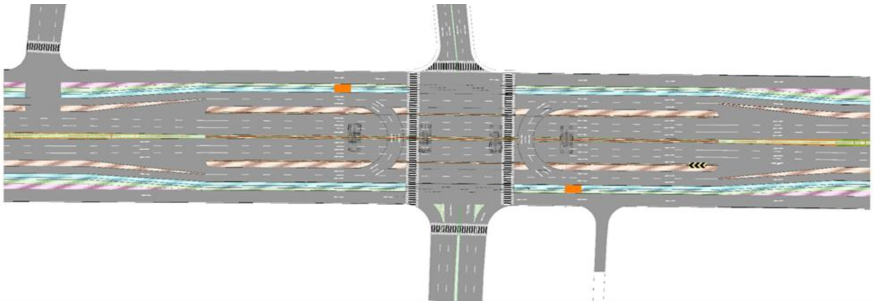


Fig 6: Proposed 2D Layout of flyover with merging, diverging & U-turn facilities

4.2 DETAILED VIEW:

Standard measurements of lane width (3.5m), shoulder width (0.6m to 1m), median (2m) provided in IRC: SP: 86-2018[IV}, Geometric Design Standards for Urban Roads and Streets (First Revision). According to IRC:3-1983[I], Dimensions and Weights of road design vehicles, no vehicle other than double decker buses shall have a height exceeding 3.8m for normal application and double decker buses may have a height not exceeding 4.75 m. According to Indian Standards, the height of flyover should be 5.5m (Fig 7 a & b).

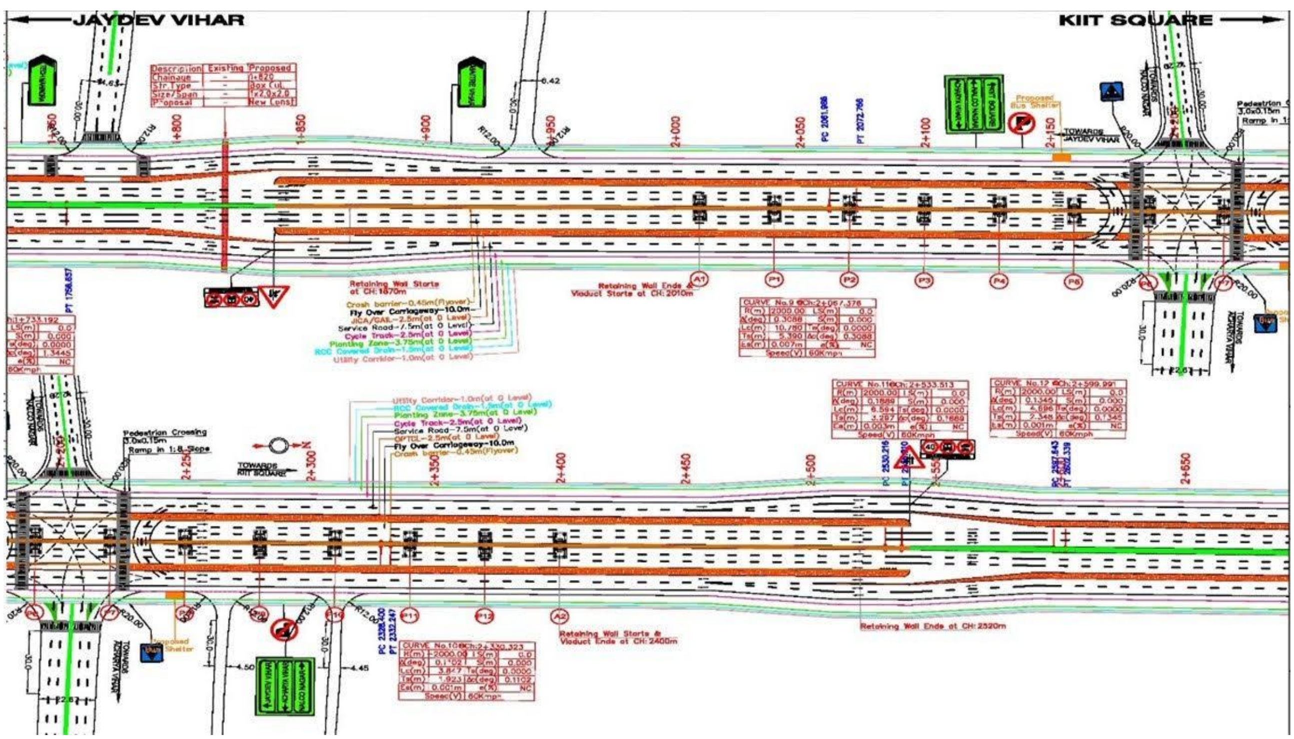


Fig 8(a): The proposed flyover from Kalinga Hospital Square to Damana Square

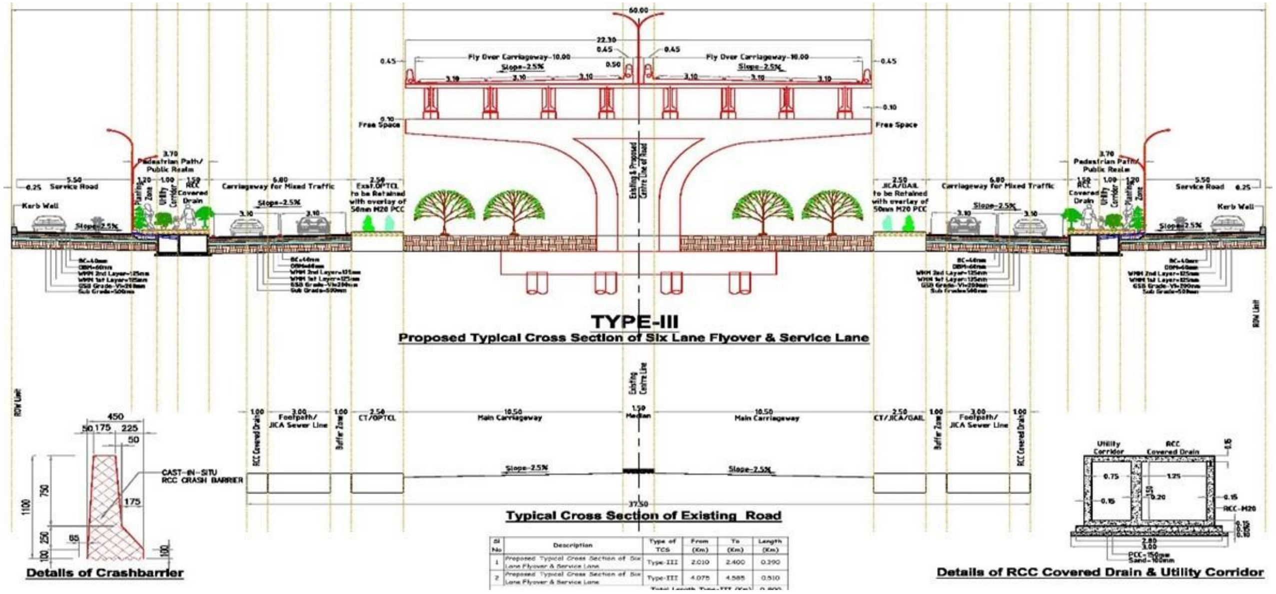


Fig 8 (b): The proposed CS of flyover from Kalinga Hospital Square to Damana Square

A Bridge with a deck slab of height of 3.5 m provided making the total height of the flyover to be 9m. Slope of the ramp generally expressed in percentages. According to IRC: 92-1985[VI, Guidelines for the design of Interchanges, the slope should be limited 4% to 6%. Therefore, providing a slope of 5% would be suitable which means a gradient of 1:20 (1m V: 20 m H). Zebra crossings and road marks shown in Fig 8 (a-e)

Fig 8 (a) Top View of the proposed Fly Over

Fig. 8(b): Side View of the proposed Fly Over

Fig 8(a – e) Zebra cross walk and road demarcation's for decelerating cars with signal timer and plan for tabletop pedestrian crossing

4.3: 3D ZEBRA CROSSWALK TO SLOW DOWN SPEEDING CARS

Innovative novice type speed bumps painted that appears to be 3D by way of a cleverly detailed optical illusion. Not only does the innovative design give foot-travelers the feeling of walking on air, but the 3D painting also gets the attention of drivers, who will be sure to slow down their speed once they spot the seemingly floating zebra stripes, **(Fig 8(a) and Fig 8(b))**

4.4 PLAN AND USE OF TABLE TOP PEDESTRIAN CROSSINGS

Stop vehicular traffic and provide pedestrian crossing phase. The new zebra crossings catch the attention of pedestrians and thereby spread awareness on road safety. The tabletop crossing will increase visibility and make road crossing easy, especially for the elderly and the disabled**, Fig 8(c).**

4.5. BROAD DESIGN FEATURES OF FLY OVER

The design data as stipulated for the proposed fly over from Kalinga Hospital square to Damana square provided in (Table 4)

Table 4: Designed data proposed broad design features of fly over (Kalinga Hos. to Damana Sq.)

#	Criterion	Design criterion	#	Criterion	Design Data
1	Direction flyover	Straight to KIIT road.	14	No. of girders	2x4Nos @ 3.20M c/c.
2	Min^{m} clearance	At junction -5.50m	15	Substructure -	Solid RCC Rect. piers.
3	No Carriageway width footpath;	Anti-crash barrier both way 3-lane divider	16	Foundation: Bored piles in situ	1200 mm diameter. Founding:22M.belowGL
4	Carriageway	Width = 10.00m	17	Bearings-	POT-PTFE as per design
5	Anti-Crash	Barrier: 2 x .45m=0.9m	18	Pier cap	-RCC Rectangular

6	Pier	C/C distance = 30.00m	19	Abutment	-RCC Rectangular.
7	Overall width	both side Anti crash Barriers– 22.30m	20	Foundation– piers and abutments	Bored cast in situ RCC piles–22m depth for.
8	All spans spacing	30m	21	Approach (solid)	RE walls on either side.
9	Max. Gradient	viaduct & approach – 1: 33	22	Drainage	Spouts provided at end of spans to collect rain
10	Camber	– 2.50% on one side.	23	Chambers	Collect rain; discharge to drains near footpath
11	Super structure -	RCC deck slab/ PSC girders	24	Lighting	Smart SPV light post
12	PSC girders	– 30m span	25	Signalling at centre of Junction	(3x30)m level spans & vertical clearance 5.50m.
13	Span arrangement	10 x 30m sloping via duct + (3 x 30) m level spans at Kalinga Hos. Sq. & 14 x 30m sloping via duct + (3 x 30) m level spans at Damana square.			

Note: POT PTFE bearing that carry vertical load by compression on an elastomeric disc confined in a steel cylinder, and which accommodates rotations by deformations of the disc

4.6: THE COMPARATIVE STUDIES

The existing, proposed for connectors and over flyover the traffic control system (TCS); such as various lanes, service roads, Kerbs, for pedestrians, cyclists, and buffer zone etc. given in Table 5.

Table 5: The existing, proposed for connectors and over flyover the traffic control system (TCS)

Existing TCS			
Description	**Nos**	**Width (m)**	**Total Width (m)**
Carriageway	2	10.50	21.00
Median	1	1.20	1.20
Cycle Track over	2	2.50	5.00
Buffer Zone	2	1.00	2.00
Footpath	2	3.00	6.00
RCC Covered	2	1.00	2.00
Total			**37.20**

Proposed TCS for Normal			
	Nos	**Width (m)**	**Total Width (m)**
Carriageway	2	10.00	20.00
Median	1	2.50	2.50
OPTCL Corridor	2	2.50	5.00
Bus Lane	2	3.60	7.20
RCC Covered Drain	2	1.50	3.00
Utility Corridor	2	1.00	2.00
Planting Zone	2	1.90	3.80
Cycle Track	2	2.50	5.00
Service Road	2	5.50	11.00
Kerb Wall	2	0.25	0.50
Total			**60.00**

Proposed TCS for Fly Over			
	Nos	**Width (m)**	**Total Width (m)**
Fly Over	2	11.25	22.50
OPTCL Corridor	2	2.50	5.00
Slip Road	2	6.80	13.60
RCC Covered Drain	2	1.50	3.00
Utility Corridor	2	1.00	2.00
Planting Zone	2	1.20	2.40
Service Road	2	5.50	11.00
Kerb Wall	2	0.25	0.50
Total			**60.00**

4.7 DISCUSSION:

Policymakers' of town planning are unable satisfy the commuters without having proper redress of the significant public policy challenge of motorization, pavement, traffic management in cities road congestion. Amidst the key skills of ICT (information and communication technologies) backing and strengthening the smart cities are basically infrastructures, large scale maps for better planning, firm connectivity, Internet of things (IOT), cloud computing, big data analytics, sensors, and artificial intelligence focusing on vast and fast technology applications and used cases with futuristic planning for transport, health, security and livelihood.

The traffic congestions, mishaps by collisions, atmospheric pollution, citizen's health, slow traffic speed, surged fuel use, fuel insufficiency, raised insurance costs are the problems of Bhubaneswar city. Growing traffic in cosmopolis are major sources of atmospheric carbon monoxides, which is strategic nanocluster of aerosols, which may demolish the future city civilization though adequate planning, infrastructures, planning, management, and smart services cosmopolis. (Troung et al., 2018[23], Toh et al., 2020[24], Rao et al., 2022[21]) (**Table 6**)

Table 6: Proposed Innovative intelligent transportation system (ITS) and respective benefits

Sl No	Innovative technologies	Benefits to be received	Source
1	On road energy harvesting; power street-lights, traffic signals & signage	Offer links of various roads; using sunlight/ Piezo electric energy harvester system through optimizing multiple structural parameters. sensors; light street dividers at night, & melting snow and ice in winter	Yang, H., et al., (2021)[25].
2	Musical roads (crop music or tunes when cars drive: Japan use musical road surface	reduce fatigue, maintain attention, slow light music boost attentiveness, in highways and long country roads; tried in USA, Japan, Netherlands, Taiwan, Denmark, and South Korea; Low level Ramblers at equal intervals produce musical sound tried in Japan	Li R., et al., 2019[26]
3	Weighing on road (Overloaded truck wane Highways)	Goods carriers need weight check in long way travel. Weights are taken static weighing, weigh-in-motion (WIM) or virtual WIM	Liimatainen et al., 2020[27]
4	Electrified roads (Auto freight charging roads)	Introduced in Sweden, Korea now in India; Electric vehicle supply Equipment (EVSE); Public charging system (PCS), Battery charging stations (BCS), Captive charging station (CCS) and Battery swapping stations (BSS) are to surge Electric vehicles as per SDG-11	https://www.niti.gov.in/sites/default/files/2021-08/ and GOI Ministry of power 12.02.2018 (Consolidated EVCI guide lines
5	Smart wireless (digital traffic	To report poor visibility, placing of vehicles; to signalise highway code signs burden of display in	Toh et al., 2018[28]

	signs) in roads	road sides, traffic signs provided by wireless system, bad weather, auto traffic volume digital information at low cost is provided and recorded	
6	finding traffic rule violation, record & notification	Multiple wireless signs (digital) eliminates traffic land mark matching using eye ; analysing the road end signs; extreme climate at least cost allow the traffic managers to the rule breakers; recording them for future use	Park et al., 2022[29]
7	V2X; CV-2X; V2X, I2X, & P2X communications & VANETs (Talking car)	Space between vehicle; car to car or traffic corridor talks or light indicators (V2V) by mobile networks can reduce traffic congestions by using IEEE 802.11p; 3GPP LTE or 5.9 GHz V2V message. E-call methods or VANET used by accident vehicles can help the trauma faced traffic and rescue architecture on emergency	Lozano et al., 2019[30] and Miao et al., 2022[31]
8	Smart street lights	Initially used Norway in 2006; the advanced adaptive street lighting systems conventional, dyna-dimmer, Chrono-sense and part-night schemes used for luminescence by local controllers, motion sensors, video-cameras, weather sensors alerting drivers of vehicles	Dizon et al., 2021[32] and Ahmed et al., 2021 [33]

5.0 ADVANTAGES AND DISADVANTAGES

The advantage of the project is that by the construction of a flyover, it avails all the benefits of traffic congestion. Flyovers with smart transportation system streamline the traffic control system like abbreviate waiting time, accidents and helps continuous flow, pollution. Flyover helps to increase the capacity of road (vehicles/km) without affecting road geometry. It enhances the aesthetic view of the city. Flyover averts conflict points at the junctions. It provides facile, expeditious and safety to public transportation service.

Flyovers contain several advantages, but there are limitations, which arise due to several mistakes committed at some stage in their construction. Flyovers are expensive and not suitable for built-up areas as they require large areas in cosmopolis. Land acquisitions are prime hindrances for its construction. Lack of proper planning, and management in the flyover construction grounds many problems. Present project deals with traffic analysis and proposing a design layout for the flyover, but not considering the detailing.

6.0 DIVERSION PROPOSAL

Smart roads, lighting, vehicles, cars, traffic signals, proper management with zero carbon pollution are the prioritized initiatives. Proper adherence to sustainable development goals (SDG goals 11) for sustainable cities and communities. The electric vehicles (EVs) commonly sighted on roads these days.

- Existing lane is six-lane road. Before starting flyover work, two lane service road (6.80m) adjacent to the existing OPTCL corridor and intermediate service road (5.50m) edge of the boundary on both side (12.3m totally) of the proposed fly over.
- Existing drains, footpath, utility services and structures falling in the service road need diversion beyond the project area on both side.
- Obstructions such as bus stops, shops, need removal before taking up the work for service roads.
- Traffic on existing six lane to continue until construction of three lanes service road on both side complete.
- The flyover portion of 22.30m need cordoned off by barricading with diversion signs need installation.
- Traffic wardens with managers need engagement for traffic management.
- Noise barriers need erection on sides of the flyover areas.
- Time of completion is 24 months (Proposed) from the date of getting clear of site, like encroachments, structures and utilities. Service roads on either side need construction prior (initial four months) and flyovers need completion in 20 months thereafter.
- The utility services need shifting in each four months interval.

7.0 CONCLUSION

Increasing demography, modernization and rapid urbanization in India have resulted in increased usage of vehicles and transportation facilities, which in turn results in traffic congestion and related problems. The project study is based on 3 main intersections and traffic data is collected manually on peak hours which is then converted to common PCU unit. After comparing peak values of 3 intersections, Kalinga Hospital and Damana Square signal junction with a highest peak value of 6114 pcu/hr is selected. Field measurements done using total station. The maximum volume a rotary can handle is 5000 pcu/hr and elevated highways can carry beyond this limit. An alternate solution suggested is the implementation of a flyover. The height of the flyover given as 5.5m based on Indian Standards. A bridge with a deck slab of height 3.5m need provision making total height of the flyover to be 9m. The length of each ramp should be 180m with a slope of 5 percent. All measurements provided as specified on IRC codes. Although governments may never be able to eliminate road congestion, with the flyover construction shall reduce certain extent and crisis can have mitigation well. Despite of the huge investment, it would provide an easy, safe and fast transportation. If the project designed as per IRC's is implemented with ITS the future demands of the traffic shall be satisfied.

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Various IRC directives and Standards followed

I. The Indian Road Congress (IRC: 03-2083) Geometric Design Standards for Urban Roads and Streets (First Revision).
II. The Indian Road Congress (IRC: SP: 90-2010), Manual for Grade separators and Elevated structures.
III. The Indian Road Congress (IRC: SP: 106-1990), Manual for Grade separators and Elevated structures.
IV. The Indian Road Congress (IRC: 86-2018) Geometric Design Standards for Urban Roads and Streets (First Revision).
V. The Indian Road Congress (IRC: SP:41-1994), Guidelines for the Design of At-Grade Intersections in Rural & Urban Areas.
VI. The Indian Road Congress (IRC:65-2017), Guidelines on Regulation and Control of Mixed Traffic in Urban Areas (First Revision**)**
VII. The Indian Road Congress (IRC: 92-1985) Geometric Design Standards for Urban Roads and Streets (First Revision).