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Reduction of CO_2 Emission at Toll Plaza with the Help of ITS (Intelligent Transportation System)

Harshavardhan U. Bhosale[*1], Sanket D. Awasare[2], Mr. M S Salunkhe[3]

[*1]Department of Technology, Shivaji University Kolhapur, Kolhapur, Maharashtra, India
[2]Department of Technology, Shivaji University Kolhapur, Kolhapur, Maharashtra, India
[3]Assistant Professor, Department of Technology, Shivaji University Kolhapur, Kolhapur, Maharashtra, India

ABSTRACT

ITS is an integrated system that implements a broad range of communication, control, vehicle sensing and electronics technologies to help in monitoring and managing traffic flow, reducing congestion, providing optimum routes to travelers, enhancing productivity of the system, and saving lives, time and money. ITS relies on wide range of technologies and functions such as Communications (Microwave, internet, Bluetooth), Geographical Locations, System, Data acquisition and exchange, Camera system and Artificial vision, Detection and classification, In-vehicle systems and Digital Mapping. Thinking of the Japanese and European thought leaders about- how ITS can contribute toward meeting environment goals - is very helpful to improve the environmental performance of ITS. Indian traffic can benefit from several possible ITS applications. One set of applications is for traffic management at toll plaza. ITS is not only helpful at toll plaza but also helpful at traffic signals, emergency management system in India. At toll plaza, deciding factor is the how much time a vehicle is going to be in the line of toll. More the time, more will be fuel consumption and waste of fuel. Knowing what kind of vehicles, and in what proportions, play main role in application of ITS at toll. ITS helps to reduce this Time factor. Also ITS clears the traffic at toll in less time. Long term data helps ITS to reduce traffic congestion at toll and reduce waste of fuel at toll efficiently.

Keywords: ITS, Microwave, Internet, Geographical Locations, Toll Plaza

I. INTRODUCTION

Intelligent Transportation System can be defined as the application of information technology to the field of transportation for achieving safety as well as mobility while reducing the environmental impact of transportation. Intelligent Transportation System consists of wide range of communication, control, vehicle sensing and electronics technologies that is helpful in monitoring and managing traffic flow, providing optimum routes to travelers, reducing congestion. ITS helps in saving lives, time and money. ITS is a smart technology and contains wide range of technology and functions such as communications like Microwave, Internet, Bluetooth. Also it depends on technologies like Camera System and Artificial Vision, Detection and Classification, Data Acquisition and Exchange and Geographical Locations. ITS is designed for all types of road transport organization including urban, state as well as private road transportation. The goal of ITS is to achieve enhanced safety and mobility as well as reducing the environmental impact of transportation. ITS not only covers all modes of transportation but also elements of transportation that includes the infrastructure, the vehicle, the driver, interacting together dynamically.

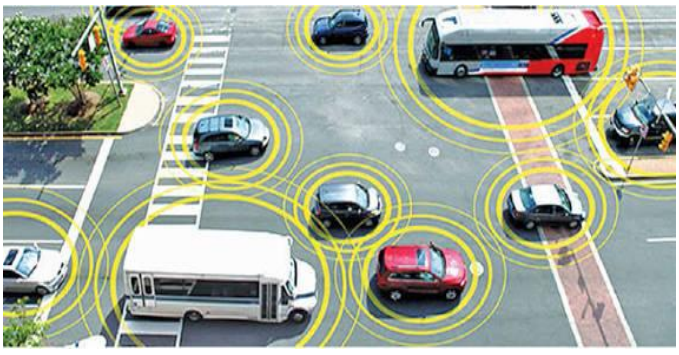


Figure 1: Intelligent Transportation System at intersection Source

II. METHODS AND MATERIAL

1. Different Techniques Used In Its

A. ATIS (Advanced Traveler Information System)

As name suggests, ATIS is the advanced system of transportation that works with the help of internet, mobile, telephone, television, radio. ATIS helps as pre-trip and on-trip manager. Pre-trip info helps to plan travel. It gives easy, accessible routes as well as nearest bus stop information which helps to plan the journey and travel. On-trip information helps during the travel. It works on real time data accessed from internet and other media. On-trip info helps to travel without any frustration which avoids rash driving of traveler.

B. ATMS (Advanced Traffic Management System)

Today traffic congestion is the problem of every metro city due to rapid growth of number of vehicles. ATMS helps to reduce this congested traffic. ATMS can be used by the traffic police department as well as traffic control department. ATMS is used to control and monitor traffic flow as well as to manage the traffic flow. The best thing about ATMS is that it uses real time information and manages traffic flow according to or with the help of traffic signals.

C. APTS (Advanced Public Transportation System)

APTS focuses mainly on public transport. APTS helps to improve public transportation with the advance technologies. APTS works on technologies like RFID (Radio Frequency Identification) as well as UHF tag (Ultra High Frequency).

D. EMS (Emergency Management System)

EMS is the combination of different ITS techniques and it is used in emergency conditions like road accidents. EMS is very helpful and it has reduced the fatality rate in the accidents. GIS technique is the most used technique in EMS as it gives the easy and accessible route in emergency condition.

E. APMS (Advanced Parking Management System)

Parking is also the problem of every metro city in the world. And with the help of APMS, parking problem is very much solved in cities like Delhi. User can get the information about vacant parking space without even entering the parking complex. APMS uses sensors as well as sign boards to notify the parking situation. Sensors look for how much vacant parking space is in parking area and display this information on the sign boards.

Figure 2: Intelligent Transportation System (Animated) Source

2. Applications of Its

ITS is developing very fast with new technologies every year. ITS is developing to increase the comfort while driving and improving accessibility.

Figure 3: Applications of ITS Source

Following are the applications of ITS to improve the transportation system:

1) Alco-lock: In alco-lock driver has to take breath test before starting the car, if BAC is too high, car will not start.
2) Seatbelt Lock: If seatbelt is not fastened, car will not start.
3) Electronic Stability Control: Electronic Stability Control gives stability to cars at edges and controls cars from skidding at edges.
4) Lane Departure Warning System: Lane Departure Warning System warns during unsafe overtaking.
5) Intelligent Speed Adaption: Intelligent Speed Adaption system warns the driver when he/she is driving at the speed that exceeding the limit.
6) Electronic Vehicle Identification: Electronic Vehicle Identification system is mainly used by police department as it can locate and follows a car in a network.
7) Electronic Data Recorder: Registers all sorts of driving behavior. It can be used both for punishing as well as for rewarding.
8) Collision Avoidance System: Collision Avoidance System warns when a moving object is detected in front of the vehicle.
9) Vehicle Detection at Intersections: Vehicle Detection at Intersections warns when crossing and gives information of vehicles avoiding collision.
10) Night Time Vision System: Improves night time vision and thus timely detection of pedestrians/cyclists. Night Time Vision System is very helpful on the platforms like national highways because there is no lamps provided on national highways, also in urban area where there is low light on road.
11) Fatigue Warning System: Fatigue Warning System is truly advance as well as smart system as it detects deviations from normal brain activity, eye movements or driving behavior and warns.
12) Forward Collision Warning System: Volvo company developed 'Forward Collision Warning System' to reduce rear crashes by giving warning on screen. This system is helping in reducing road accidents.
13) Vehicle Lane Departure Prevention System: In Japan, Nissan motor company developed 'Vehicle Lane Departure System' to keep vehicles in lane which avoid traffic congestion. This system has shown great results.

3. Toll Plaza

Toll System is used to collect toll tax that recovers the total capital expenditure which includes the cost of construction, repairs, maintenance, expenses on toll operation and interest on the expenditure. The new facility then constructed should provide less travel time and increased level of service. In India almost all of the highway projects are given on PPP basis, i.e. Public Private Partnership. In this system, the private organization constructs the facility with their own finance and recovers the capital from the users in the form of toll tax. This tax is collected for a reasonable period of time and after which that facility is surrendered to the public. Of late, toll tax is being levied on parking of vehicles in the urban centers for the purpose to reduce congestion on the streets and to reduce the pollution levels. This method is known as Congestion Pricing.

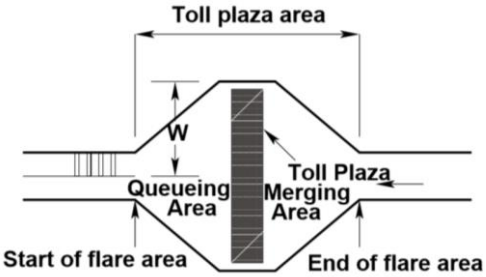


Figure 4: General Layout of Toll Plaza Source

4. Types of Toll Collection

There are two types of toll collection systems available. These systems are (i) Open Toll System, and (ii) Closed Toll System.

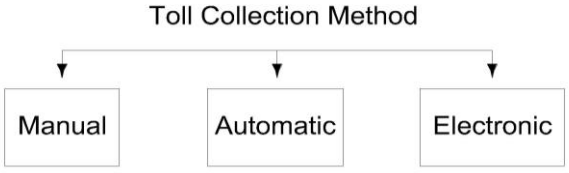


Figure 5: Toll Collection Methods

A. Open toll System

In an open toll system, not all vehicle users are charged a toll. In this system, the toll plaza is generally located at the edge of the urban area, where a majority of long

distance travelers are using this facility, with a minimum likelihood of switching to the parallel free route, or at the busiest section of the toll way. Vehicle users are identified by their category of vehicle . Toll price is base on the category of vehicle. And user pays a fixed toll according to his/her type of vehicle. The local traffic around the plaza either gets rebate or can use a service lane.

B. Closed toll System

In a closed toll system, price of toll is based on miles of travel on the facility and the category of vehicle. There are no free-rides. In a closed toll system, toll plazas are provided at all the entry and exit points, with the users receiving a ticket upon entering this system. When exiting, users give their ticket to the collector and is charged a fee based on category of vehicle and distance travelled by the users. This system contains only two stops for the vehicles on the other hand open system contains multiple stops. But the drawback of the closed system is that it is expensive to construct than open system.

C. Number of Toll lanes

As mentioned previously, toll plazas are installed to collect the tax from the road users. The number of toll plazas depends on the flow of vehicles on the facility. Following guidelines are generally followed while deciding the number of toll lanes at a toll plaza:

1) Peak Hour Factor: It is the percentage of vehicles travelling during the peak hour to the average daily traffic.
2) Number of toll lanes should be corresponding to the forecast traffic for at least 5 years.
3) Forecast traffic in terms of veh/day for all the tollable categories. Non-tollable vehicles (e.g. VIP vehicles, ambulances, etc) are exempted from the toll tax and flow through a separate lane.
4) If the queue becomes so long that the waiting time exceeds three minutes then the number of tollbooths need to be increased.

D. Tollbooth

A tollbooth is the location at the toll plaza where the tax is actually collected. . Following guidelines are generally followed during construction of tollbooth:

1) Toll booths should be made from prefabricated materials or of brick masonry.
2) Toll booth should have space for seating for toll collector, computer system, printer and cash.

E. Toll Pricing

Toll is a tax collected for the use of the road, bridge, tunnel, etc. to recover the total expenditure which includes interest on expenditure, cost of repairs, maintenance and also expenses on collection of toll. It is important that the amount of toll should not exceed the benefits which the user receive while using the that facility. The benefits are provided to reduce travel time, travel cost, increase in comfort and convenience. The toll structure should be fixed in such a way that investments and expenses are recovered within a reasonable period of time. The product of optimum toll rate and traffic volume finally determines the gross toll revenue.

F. Factors Affecting Toll Rates

Two important factors determine the toll rates. They are:

1) Traffic Volume: Traffic volume that will be using the facility is the most important factor. There for traffic volume is determined. Success of any toll depends on the accurate estimation and forecasting of toll traffic at facility and its composition.
2) Willingness to pay: Users will be willing to pay a realizable portion of their savings to use the improved facility.

5. Toll Plaza: India

Construction and maintenance of toll plaza on national highways comes under authority of NHAI. NHAI (The National Highway Authority of India) was constituted by an Act of Parliament, the National Highways Authority of India Act, 1988. It is responsible for the development, maintenance and management of National Highways entrusted to it and for matters connected or

incidental there to. The Authority was operationalized in Feb, 1995. There are 377 toll plaza in India and out of which 70% of toll plaza will be having ETC system soon.

Figure 6: Network of National Highway (India)

Roads having toll plazas (India):

A. Maharashtra
1) Mumbai-Pune Expressway, Mumbai
2) Western Expressway, Mumbai
3) Eastern Expressway, Mumbai
4) Sion Panvel Expressway, Mumbai
5) Western Freeway, Mumbai
6) Eastern Freeway, Mumbai
7) Mumbai–Vadodara Expressway, Mumbai to Gujarat
8) Mumbai Nashik Expressway, Mumbai to Nashik
9) Pune to Satara
10) Satara to Karad to Kolhapur
11) Pune to Solapur
12) Airoli to Mulund

B. Delhi
1) DND Flyway
2) Delhi-Gurgaon Expressway
3) Noida-Greater Noida Expressway
4) Taj Expressway
5) Ganga Expressway
6) Delhi Faridabad Skyway

C. Uttar Pradesh
1) Taj Expressway (Under Construction)
2) Ganga Expressway (proposed)
3) Kanpur Metropolitan Expressway (Under Construction)

D. Karnataka
1) NH 4 from Nelamangala till Maharashtra border
2) NH 4 from K.R Puram till Tamil Nadu
3) NH 48 from Nelamangala till Hassan
4) NH 13 from [Vijapur] till Koppal
5) Bangalore - Electronic City Expressway
6) Bangalore - Nelamangala Expressway
7) Bangalore - Kempegowda International Airport(KIA) Expressway

E. Tamil Nadu
1) East Coast Road (ECR) from Chennai to Pondicherry
2) Chennai Bye Pass Road from Irumbuliyur, Chennai to NH4 Madhavaram, Chennai
3) Chennai ECR - Sholinganallur Road from ECR, Chennai to Sholinganallur, Chennai
4) Chennai OMR - Medavakkam Road from Sholinganallur, Chennai to Medavakkam, Chennai
5) NH 47 Salem to Coimbatore Expressway / Industrial Corridor
6) NH 67 Coimbatore to Trichy
7) NH 7 Hosur to Krishnagiri
8) NH 4 Krishnagiri to Chennai
9) NH 45 Chennai to Villupuram
10) NH 7 Krishnagiri to Salem
11) NH 45B Madurai to Tuticorin (Nearing completion)
12) NH 45 Dindigul to Trichy
13) NH 45 Villupuram to Trichy
14) NH 7 Salem to Madurai (Nearing completion)
15) NH 7A Tirunelveli to Tuticorin
16) Chennai to Ennore Express Way (Inner Ring Road & Manali Oil Refinery Rd.)
17) NH 45B Madurai to Trichy
18) NH 67 (Trichy) to (thanjavur)
19) NH 7 (Dindigual) to (karur) TNDK toll plaza

F. Telangana
1) Hyderabad Outer Ring Road Expressway

2) Hyderabad to Mancherial
3) Adilabad to Kurnool (AP) (NH 7, New NH 44)
4) Hyderabad to Raigiri (NH 202, New NH 163 towards Warangal)
5) Sangareddy (Hyderabad) to Vijayawada (AP) (NH 9, New NH 65)
6) Hyderabad to Damarcharla

G. Andhra Pradesh

1) National Highway 5 (New NH65) (Tada to Srikakulam)
2) Kurnool to Bangalore (KA) (NH 7, New NH 44)
3) Kurnool to Kadapa (Rayalaseema Expressway)
4) Kodad (TG) to Vijayawada (NH 9, New NH 65)
5) Eluru NH5 (New NH65)
6) Tanuku NH5 (New NH65)

6. Toll Collection Methods

A. Manual Toll Collection

Manual toll collection is the conventional method of toll collection. In India, all toll plazas are having this method for toll collection. This method requires man-power. It requires toll attendant. Base on the type of vehicle, toll is collected by the attendant. Then attendant gives the ticket to vehicle user. Operation time is high for this method. At the peak hour of traffic, there can be long queues of vehicles may happen.

Figure 7: Manual Toll Collection

B. Electronic Toll Collection

Electronic toll collection is advance version of manual method of toll collection. It relies on technologies like RFID (Radio Frequency Identification Technology), Android, Bluetooth, Sensors, GPS etc This system doesn't require any man-power as it automatically collects toll from vehicle user. When vehicle approaches toll plaza, sensors detects the type of vehicle by sensing the tag on the vehicle provided to user by the authority of toll plaza. Then the amount of toll is deducted from user's account and then user receives a SMS of amount deduction from bank. Then gate opens and user is ready to go. Operation time is less as compared to manual method of toll collection.

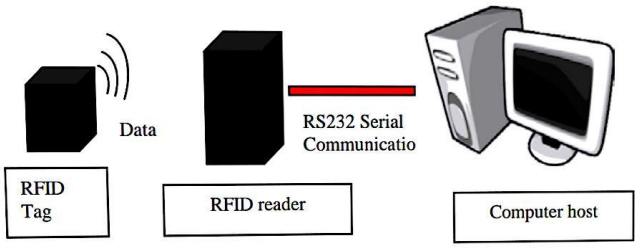


Figure 8: Toll Collection using RFID Technology Source

Figure 9: Barcode Laser Technology

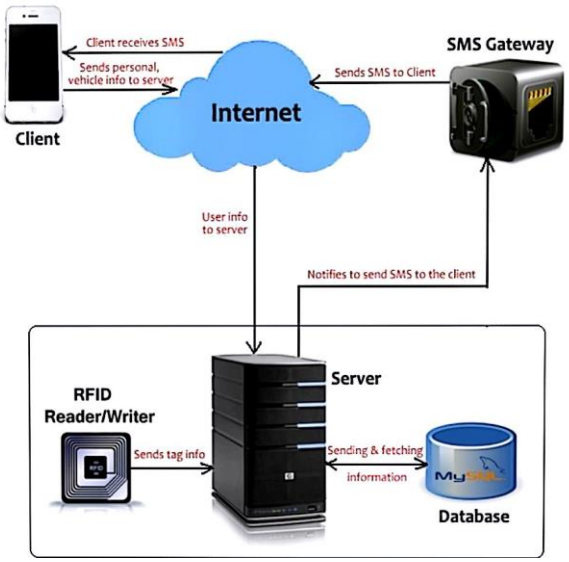


Figure 10: ETC Using NFC and Android Application

C. Open Road Toll Collection

Open Road Toll collection method is the method where there is no toll plaza is required. In this method neither man-power nor gates are provided. User doesn't require slowing down his speed when approaching this system. User need not to stop at this system and can retain his speed. Hence there is no queue problem or traffic congestion at this system. This is the most advance method of toll collection and efficient method as it provides maximum vehicles per hour through the facility. Only disadvantage of this method is the possibility of violators who do not pay. This leakage may either be written off as an expense by the toll operator or offset in part or whole by fees and fines collected against violators.

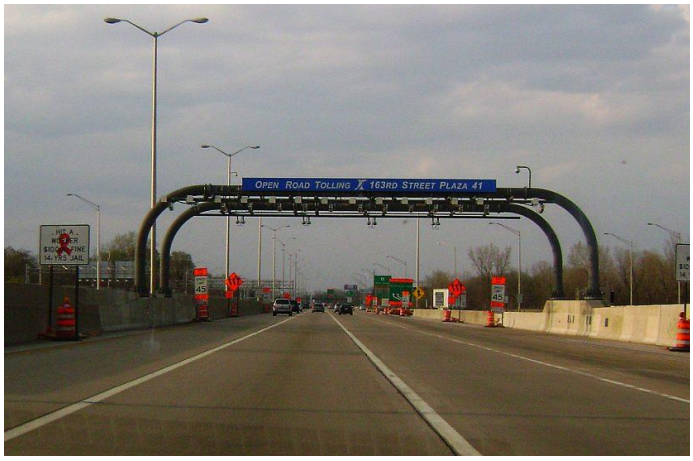


Figure 11: Open Road Tolling Source

7. Method for Calculation of Road Transport Emission

The methodology for the estimation of CO2 emissions applied to the case of the Indian toll road network is based on COPERT IV, which is a European tool for the calculation of emissions from the road transport sector. The framework of methodology is shown in Fig.

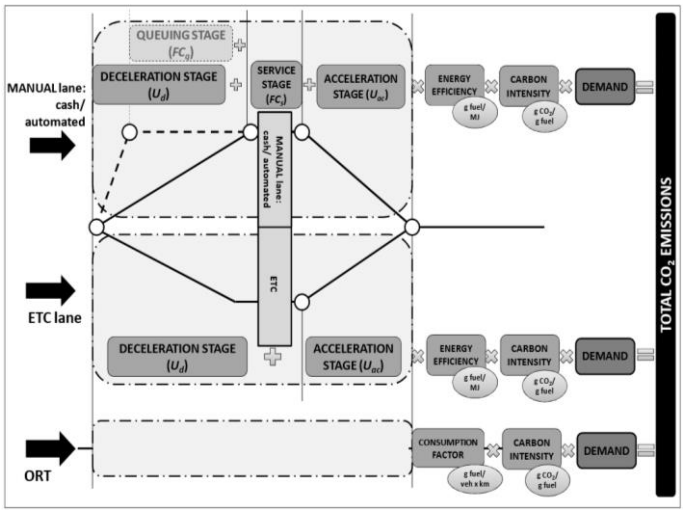


Figure 12: The framework of methodology for estimating emission of CO_2

In this method the total operation is divided in stages. For Manual method, the stages are Deceleration, Service and Acceleration stage. For ETC, stages are same as manual method. But for ORT there is no requirement of division of stages as this method eliminates barriers altogether and allow vehicles to travel through toll collection points without deceleration, thereby maintaining their speed.

8. Calculations

A. Description Of Study Area

Location:
Kognoli Toll Plaza,
NH4, At Post- Kognoli
Karnataka-Maharashtra Border
Tal.-Chikodi, Dist.-Belgaum-591 215,
India

Name of the Contractor:
Ashoka Concessions Ltd.

Name and Address of Principle Employer:

National Highway Authority of India
2nd Cross Road, Sattur Colony,
Vidyanagari, Dharwad

The toll plaza is having 5 lanes on each side for toll collection. Out of which 1 lane is provided for ETC but it has not been started yet. ETC is opening soon,here. For ETC they have installed FASTag reader sensors that works on RFID (Radio Frequency Identification Technology) technology and given the separate lane. Right now they are using conventional method, i.e. Manual Toll collection method, for toll collection.

Figure 13: Kognoli Toll Plaza

Figure 14: FASTag reader for ETC at Kognoli Toll Plaza

Figure 15: Separate Lane for ETC at Kognoli Toll Plaza

9. Deceleration Stage

Deceleration stage is the stage where vehicles decelerate because they are approaching the toll plaza. For calculation purpose the area for this stage is fixed as 100 feet. At the end of this stage there is toll booth. And at the end of the stage speed of vehicle is minimum. To calculate the time in this stage, readings of 20 vehicles are taken with the help of stopwatch:
Following are the readings taken at toll plaza

a) For Manual toll collection

Table 1: Deceleration Time at Manual Toll Method

Vehicle Number	Time (sec)
1	26
2	26
3	27
4	32
5	27
6	26
7	30
8	32
9	28
10	26
11	27
12	28
13	27
14	28
15	26
16	30

17	26
18	30
19	32
20	32
Avg.	= 28.3

Hence, Average Time = 28.3 sec

b) For ETC

Type of Vehicle	Average Time
Car	8
Bus	8
LDV	10
HDT	16

Here,

LDV = Light Duty Commercial Vehicle (Truck),

HDT = Heavy Duty Truck

c) For ORT

There is no deceleration stage for ORT. Hence no deceleration time for ORT.

10. Service Stage

This is the stage where vehicle stops to pay the toll. Toll is fixed according to type of vehicle. Service stage requires time for payment of toll and receiving the receipt from toll booth. To calculate this service time, readings of 20 vehicles are taken with the help of stopwatch:

Following are the readings taken at toll plaza.

a) For Manual toll collection

Table 2 : Service Time for manual

Vehicle Number	Time (sec)
1	20
2	22
3	25
4	30
5	20
6	30
7	25
8	25
9	30
10	20
11	20
12	30
13	25
14	22
15	20
16	22
17	25
18	20
19	25
20	22
Avg.	23.9

Hence, Average Time = 23.9 sec

b) For ETC

Average Time = 3-5 sec

Assume, service time for ETC = 4 sec

c) For ORT

There is no toll booth installed for ORT. Hence no service time for ORT.

11. Acceleration Stage

Acceleration stage is the stage where vehicles accelerate because they are leaving the toll plaza. For calculation purpose the area for this stage is fixed: 100 feet. At the starting point of this stage there is toll booth. And at the end of the stage speed of vehicle is maximum. To calculate the time in this stage, readings of 20 vehicles of each type are taken with the help of stopwatch.

Following are the readings taken at toll plaza

a) For Manual toll collection

Table 3: Acceleration Time for Car

Vehicle Number	Time (sec)
1	11
2	12
3	10
4	15
5	10
6	12
7	11
8	12
9	11
10	10

11	9
12	9
13	9
14	9
15	9
16	10
17	12
18	9
19	11
20	11
Avg.	10.6

Hence, Average Time of Car = 10.6 sec

Table 4: Acceleration Time for Bus

Vehicle Number	Time (sec)
1	13
2	15
3	15
4	14
5	16
6	13
7	15
8	16
9	15
10	15
11	14
12	14
13	15
14	15
15	16
16	15
17	14
18	15
19	16
20	13
Avg.	14.7

Hence, Average Time of Bus = 14.7 sec

Table 5: Acceleration Time for LDV

Vehicle Number	Time (sec)
1	16
2	15
3	18
4	15
5	15
6	15
7	17
8	21
9	15
10	16
11	16
12	18
13	16
14	18
15	16
16	17
17	16
18	18
19	16
20	17
Avg.	16.55

Hence, Average Time of LDV = 16.55 sec

Table 6: Acceleration Time for HDT

Vehicle Number	Time (sec)
1	25
2	20
3	17
4	21
5	22
6	24
7	22
8	24
9	23
10	21
11	22
12	24
13	22
14	24
15	21
16	22
17	23
18	24
19	21
20	22
Avg.	22.2

Hence, Average Time = 22.2 sec

b) For ETC

Acceleration stage is same for both manual and ETC.

Type of Vehicle	Avg. Acceleration time (sec)
Car	10.6
Bus	14.7
LDV	16.55
HDT	22.2

c) For ORT

There is no acceleration stage for ORT. Hence no acceleration time for ORT.

12. CO_2 Intensity

Data of CO_2 emission from vehicles in idling position is taken from the source: "Indicative Impacts of Vehicular Idling on Air Emissions" by Dr. Sarath Guttikunda. Here CO_2 emission is calculated for diesel, petrol and CNG vehicles. CO_2 emission of vehicles is given in the form of gm/day/vehicle:

Table 7: CO2 intensity for vehicles

	Gasoline			Diesel				CNG			
	2Ws	3Ws	Cars	Cars	LDV	HDT	Bus	3Ws	Cars	LDV	Bus
PM_{10}	1.0	3.3	0.4	4.7	5.0	12.0	9.0	1.7	0.2	0.1	0.1
$PM_{2.5}$	0.5	1.3	0.1	2.8	2.0	6.0	4.8	0.8	0.1	0.0	0.1
SO_2	0.2	0.3	0.3	1.9	1.2	6.0	6.0	0.0	0.0	0.0	0.0
NO_x	1.5	1.7	0.8	5.8	8.0	60.0	60.0	5.8	0.8	10.5	15.0
CO	25.0	133.3	20.0	9.3	10.0	21.0	21.0	58.3	4.0	10.5	21.0
CO_2	400	1333	800	1167	2000	5100	5100	1167	400	1350	2700
HC	15.0	83.3	4.0	1.9	0.8	6.0	6.0	2.5	0.1	0.3	0.6

Above table is having readings given in form gm/day/vehicle type. As it is given in day, it is converted in seconds for calculation purpose. Following table is showing CO_2 emission for gm/sec/vehicle type:

Table 8: Conversion of CO_2 from gm/day to gm/sec

Vehicle Type	CO_2 emission in gm/day	CO_2 emission in gm/sec
Car (Petrol)	800	0.0092
Car (Diesel)	1167	0.0135
Car (CNG)	400	0.0046
Bus	5100	0.0590
Truck	2000	0.0231

13. Traffic Volume Count

Traffic volume data at toll plaza is calculated using Manual Traffic Volume Count Method. This readings are taken on the toll plaza on 26th May 2016 from 1.00 p.m. to 2.00 p.m. For counting purpose vehicles are divided in three types: Car/jeep, Bus and truck. Two wheelers and three wheelers (rickshaws) are not considered here. Traffic volume for ETC is not calculated because it is in still progress and not started at this toll plaza yet. In the direction towards Kolhapur.

Table 9: Traffic count (Upward)

Vehicle Type	Vehicle Count
Car	286
Bus	32
LDV	90
HDT	48
Total	456

In the direction towards Belgaum

Table 10: Traffic count (Downward)

Vehicle Type	Vehicle Count
Car	281
Bus	29
LDV	96
HDT	48
Total	454

14. Total CO_2 Emission

Total CO_2 emission is the product of time required for deceleration plus time required for service time plus time required for acceleration multiplied by carbon intensity and vehicle number. Total CO_2 emission is calculated in gm. Following is the detailed calculation of CO_2 emission for Manual, ETC and ORT.

Formula for CO2 emission for Manual toll collection:

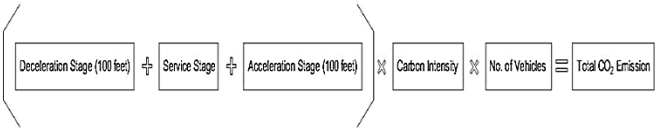


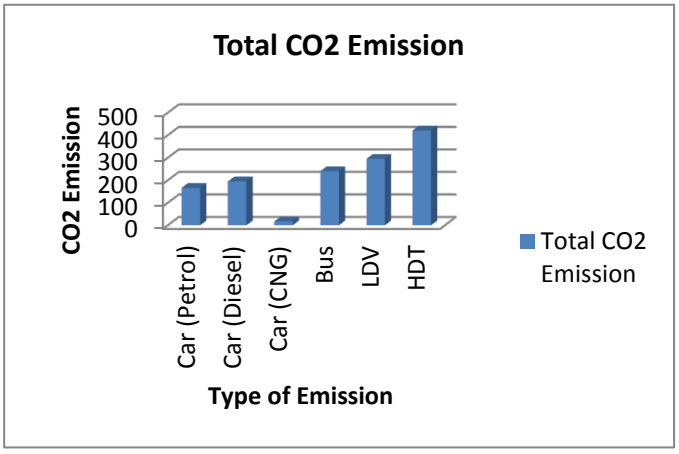
Figure 16: Formula of CO2 Calculation for Manual Toll

Total CO_2 emission = {(Deceleration time + Service time + Acceleration time) x Carbon intensity x Number of vehicles}

Table 11: Total CO_2 emission for Manual toll collection

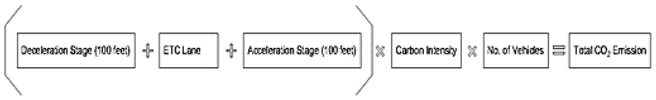
Vehicle Type	Deceleration Time (in sec)	Service Time (in sec)	Acceleration Time (in sec)	Carbon Intensity (in gm/sec)	Total Vehicle Count	TOTAL CO2 EMISSION (in gm)
Car (Petrol)	28.3	23.9	10.6	0.0092	288	166.39
Car (Diesel)	28.3	23.9	10.6	0.0135	230	194.99
Car (CNG)	28.3	23.9	10.6	0.0046	59	17.04
Bus	28.3	23.9	14.7	0.0590	61	240.77
LDV	28.3	23.9	16.55	0.0231	186	295.39
HDT	28.3	23.9	22.2	0.0590	96	421.40
					Total	**1412.21**

Total CO2 emission = 1412.21 gm



15. Formula for CO_2 emission for ETC

Formula for ETC:

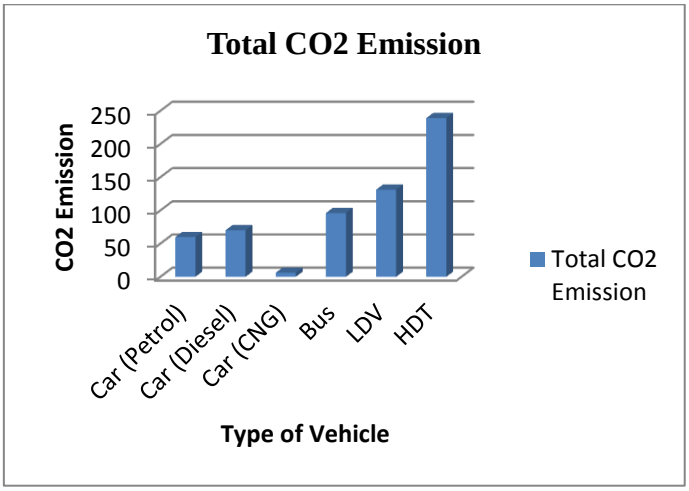


Total CO_2 emission = {(Deceleration time + Service time + Acceleration time) x Carbon intensity x Number of vehicles}

Table 12: Total CO_2 emission for ETC

Vehicle Type	Deceleration Time (in sec)	Service Time (in sec)	Acceleration Time (in sec)	Carbon Intensity (in gm/sec)	Total Vehicle Count	TOTAL CO_2EMISSION (in gm)
Car (Petrol)	8	4	10.6	0.0092	288	59.88
Car (Diesel)	8	4	10.6	0.0135	230	70.17
Car (CNG)	8	4	10.6	0.0046	59	6.13
Bus	8	4	14.7	0.0590	61	96.09
LDV	10	4	16.5	0.0231	186	131.26
HDT	16	4	22.2	0.0590	96	239.02
					Total	602.55

Hence Total Emission CO_2 = 602.55



16. CO_2 Emission for ORT

There is no need of calculation of CO_2 emission for ORT because this method eliminates barriers altogether and allow vehicles to travel through toll collection points without deceleration, thereby maintaining their speed.

17. Electricity Generation Using Speed Breaker

A. Introduction

Today we all depend on electricity. It is the essential part of human life. But with the increasing population, use of electricity is also increasing. The problem is that the resources of electricity generation are limited. Hence we are facing electricity crisis. We must find other methods of electricity generation. In this project, the attempt is done to generate electricity using speed

breaker. Today vehicle number is increasing day-by-day, hence using this method we can generate electricity on large scale. The mechanism used for electricity generation is very simple and basic.

B. Principle of Working

The principle of the electric power generation using this method is very simple. It is based on the same principle which is in the case of electricity generation of hydroelectric power plant, thermal electric power plant, nuclear power plant, geothermal energy power plant, wind mill, tidal energy power plant etc. In all of the above mentioned power plant, principle used is that the mechanical energy is converted into electrical energy. In the method used here, there is also same principle that is mechanical energy is converted into electrical power using a D.C. generator. Here the vertical motion of the top of the speed breaker is converted into the rotational motion. Then it rotates the generator and electricity is generated.

C. Name of the Components

Table 13: Name of the Components

Sr. No.	Name of the component
1	Battery
2	Bearing
3	Chain Drive
4	D. C. Generator
5	Gear
6	Inverter
7	Shaft
8	Spring

D. Components List With Their Specification

Table 14: Components List with Their Specification

Sr. No.	Name of the component	Specification
1	Bearing	Type: Rolling Contact Bearing, Bearing no. N40
2	Chain and Sprocket	Number of Teeth on Big Sprocket: 48 Number of Teeth on small Sprocket: 19 Distance between the Center 16 cm
3	Gear	Material: Number of Teeth on Big Gear: 56 Number of Teeth on small Gear: 48 Type: Spur Gear Number of gear Used: 2
4	Motor	Voltage: 12 Type: D.C. Generator RPM: 1200
5	Shaft	Diameter: 8 mm Material: Mild Steel Length: 381 mm
6	Spring	Load Bearing Capacity: 6-7 kg Material: Mild Steel Total Displacement: 2 inch

E. Construction

In this method, speed breaker is connected to bearing which is carried by a projection from U-shaped shaft. The bearing is provided in such a way that it allows the relative motion between shafts. Therefore the vertical motion is converted into rotational motion. The speed breaker gets displaced in downward direction after that it retains its original position because it is provided with the return spring. This spring is designed according to the weight of vehicles passing through that facility. The two ends of shafts are fixed by bearing. This shaft is made of mild steel. This shaft is provided with the sprocket because it rotates in direction of the shaft. This sprocket is connected with another sprocket with the help of chain drive and it is mounted on the other shaft. This mechanism is like the bicycle arrangement. The lower shaft is also provided a gear. This gear is mounted on the generator and it is meshing with gear on the lower shaft. It helps to rotate the D.C. generator and in turn it generates electrical power, which is stored in the battery and it can be used accordingly. The type of generator used in this method is permanent magnet D.C. generator. This generate is having voltage of 12 Volt D.C. and this is stored in the lead battery of 12 Volt. This battery is connected to the inverter. This inverter is used to convert this 12 volt D.C. to the 230 volt A.C. voltage and it is

used to run the light fan etc. With increase in the capacity of the battery and the inverter circuit, the power rate increases. This arrangement can be fitted in highways and the complete arrangement is kept inside the floor level of highways except the arrangement of speed brake.

F. Block Diagram

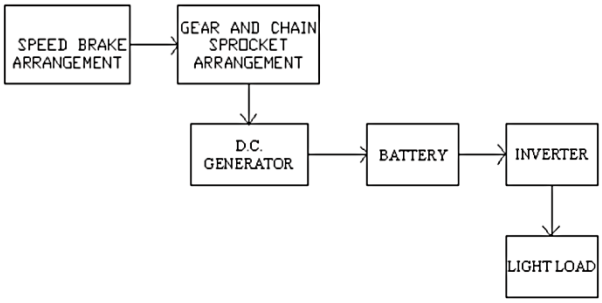


Figure 17: Block diagram

G. Working of Model

The working of this method for producing electricity is very simple. There are a huge number of vehicles running on the road. These vehicles go over a number of speed breakers installed on the road by this system. The weight of vehicle varies according to the type of vehicles like cars, bus, trucks, and two wheelers. Therefore whenever they are passing over a speed breaker a lot of energy is wasting every day. So when the vehicle passes over the speed breaker because of the weight of vehicle, the top portion of the speed breaker moves in the downward direction and the shaft consisting of the U portion rotates in a particular direction. Due to which the sprocket rotates and then rotational energy from one shaft is transferred to the other shaft with the help of chain drive mechanism. This help to rotate the gear on the bottom shaft due to which it helps to rotate the gear placed on the motor. This rotation of the gear starts the generator and electricity is generated. And it is stored in the battery. It can be converted in a.c. current with the help of inverter and it used for lighting of the lamps, signals as well as sign. When the vehicles have passed over the speed breaker, it retains its original position with the help of the return spring provided and then the chain drive rotates in the reverse direction without rotating the gears just like the mechanism in bicycle as in case of the bicycle. The important fact to notice that power gets generated only during the downward motion of speed breaker and not in the reversed motion of the speed breaker. The power generated can be used in many places, which varies in the voltage from 12-230 volts.

H. Power Calculations

Let us consider,
The mass of any vehicle travelling over the speed breaker= 100 Kg (Approximately)
Height of speed breaker = 15 cm
Work done = weight of the body x distance travelled by the vehicle
Here, Weight of the Body = 100 Kg x 9.81 = 981 N
Distance traveled by the body = Height of the speed breaker = 15cm
Power = Work done/Second = (981 x 0.15)/60 = 2.45 Watts
Output Power developed for 1 vehicle passing over the speed breaker arrangement for one minute = 2.45 watts
Power developed per second = 0.0408 watts
Following is the calculation of power generation for the traffic at the Kognoli toll plaza:

Table 15. Calculation of Power Generation for the Traffic on Kognoli Toll Plaza (For Upward Direction)

Type of Vehicle	Mass of Vehicle without any luggage (in kg)	Weight of Vehicle (in N)	Height of Speed Breaker (in cm)	Power (in Watts) = Wt. of Vehicle x Ht. of Speed Breaker	Power per second (in Watt)	Number of Vehicles	Total Power Generated = Power x Number of Vehicles
Car	1500	1500 x 9.81	0.15	36.78	0.61	286	174.46
Bus	18000	18000 x 9.81	0.15	441.45	7.35	32	235.20
HDT	30000	30000 x 9.81	0.15	735.75	12.26	48	588.48
LDV	18000	18000 x 9.81	0.15	441.45	7.35	90	**661.50**
						TOTAL	**1659.64**

Hence, Total Power generated in upward direction i.e. Traffic Towards Kolhapur = 1659.64 Watt

Table 16: Calculation of Power Generation for the Traffic on Kognoli Toll Plaza (For Downward Direction)

Type of Vehicle	Mass of Vehicle without any luggage (in kg)	Weight of Vehicle (in N)	Height of Speed Breaker (in cm)	Power (in Watts) = Wt. of Vehicle x Ht. of Speed Breaker	Power per second (in Watt)	Number of Vehicles	Total Power Generated = Power x Number of Vehicles
Car	1500	1500 x 9.81	0.15	36.78	0.61	281	171.41
Bus	18000	18000 x 9.81	0.15	441.45	7.35	29	212.86
HDT	30000	30000 x 9.81	0.15	735.75	12.26	48	588.48
LDV	18000	18000 x 9.81	0.15	441.45	7.35	96	**705.60**
						TOTAL	**1678.35**

Hence, Total Power generated in downward direction i.e. Traffic Towards Belgaum = 1678.35 Watt
Hence, Total Power generated = 1659.64 + 1678.35 = 3337.99 Watt

This power is sufficient enough to run a bulb of 250 Watt for hours. This power is generated for the vehicles counted only for 1 hour only at Kognoli Toll plaza. Power generated, here, is large in amount hence we can provide more bulbs and this bulbs can be used for whole night (for 12 hours) without fail.

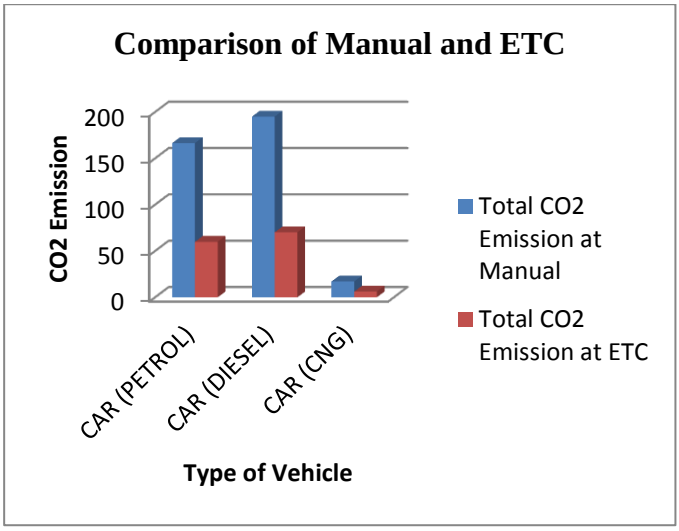
I. Applications

Power generated in this method can be used for following purposes:

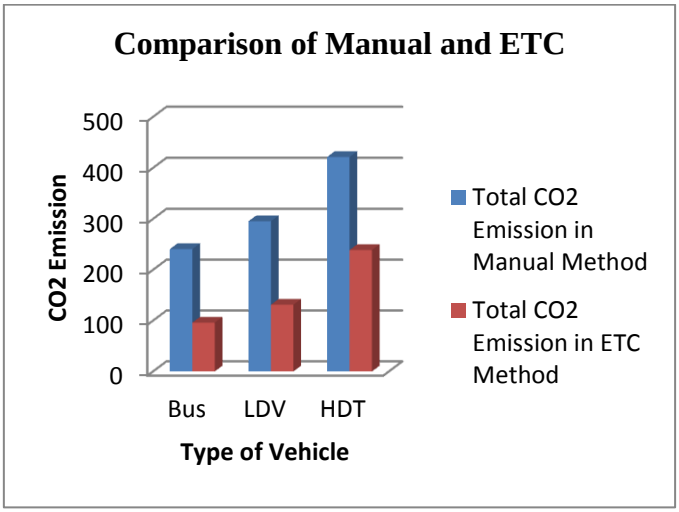
- To run lamp posts on highways,
- To run the total operation of toll plaza,
- To run sign boards on highways,

III. RESULT AND DISCUSSION

Following is the comparison of Total CO_2 emission of Car (Petrol), Car (Diesel) and Car (CNG) for Manual, ETC:



Following is the comparison of Total CO_2 emission of Bus, LDV and HDT for Manual, ETC:



From graph it is clear that Manual toll method is the least efficient method of all.
Total CO_2 emission calculation:
Manual (Peak Hours): 1412.21 gm
ETC: gm
ORT: 0 gm
As we can see, there is huge difference between CO2 emission of manual and other methods. Comparing to manual, ETC and ORT systems are emitting very less CO_2. This CO_2 emission is only for vehicles counted for only one hour. We are wasting this much CO_2 in only one hour at only one toll due to manual method. And there are 377 toll plazas only in India that means we are emitting huge amount of CO_2 due to this manual method in India. It may be tones of CO_2 emission per hour, globally. And this CO_2 is affecting on environment causing increase of temperature. Hence, we have to switch from Manual method to ETC/ORT.

Future Scope

- The method of calculation of CO_2 emission used in this project can also be also used to calculate the emission of exhaust gases like PM10 , PM2.5 , SO_2 , NOX , CO, CO_2 , HC
- Also the method of electricity generation by using speed breaker can also be used at traffic signals also.
- Also the method of electricity generation by using speed breaker can also be used to generate electricity which can be provided to near villages also.
- This principle can also be used in the steps of the staircase to produce electricity. In which whenever a person puts his foot on the step due to his/her weight the step gets displaced in the downward direction

and it will rotate the rotor of the generator in same manner similar to speed breaker arrangement. This electric power can be generated and it can be used in the buildings.

- We can provide the speed breaker at regular interval along whole national highway, and it can provide light at night time.

IV. CONCLUSION

A. The Most Efficient Method For Toll Collection

- Emission of CO_2 at ETC is very less than manual method but there is no CO_2 emission at ORT. The above graphs reveal that ORT system leads to reduction of up to 70% of CO_2 emissions at toll plazas, while ETC system reduces 20% comparing to the manual ones.
- Also ORT leads to saving of time up to 63 seconds more than Manual method and 22.6 seconds more than ETC.
- Also no installation of toll booth is necessary for ORT as well as no need of manpower.
- Last but not the least, saving of paper is there which clearly shows that the ORT is more eco-friendly than the rest.
- No doubt ORT is the most efficient method of toll collection as it saves time, there is no wastage of fuel, and very less CO_2 is emitted and there is saving of paper.

B. Electricity Generation Using Speed Breaker

- The power generated by vehicles is more than sufficient to run street lights in the night time.
- Power generation using speed breaker system can be used in the following:
  - Street Lights.
  - Road Signals.
  - Sign boards on the roads.
  - Lighting Of the bus stops.
  - Lighting of the check post on the highways etc.

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