Research Article

Role of Accident Prediction Model in Finalising the Improvements to Reduce the Accident Rate

G. Athipathi[a], S. Nagan[*], T. Baskaran[**]

[a]Doctoral Scholar, Department of Civil Engineering, Noorul Islam University, Kumaracoil, Thuckalay, Tamilnadu, India.
*Associate Professor, Dept of Civil Engg, Thiagarajar College of Engineering, Thirupparankundram, Madurai, Tamilnadu, India.
**Assistant Professor, Department of Civil Engineering, Thiagarajar College of Engineering, Thirupparankundram, Madurai India.
***Corresponding author's E-mail:** athipathi@yahoo.com

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ABSTRACT

Now a days, both the Central & State Government of India is committed to reduce the increase in Accident rate in India. Many scholars around the world and in India have made several attempts to predict the accident. As we all are aware that there are many factors which contribute in reduction of the accident rate. With the prediction of the accidents, it would be possible for the stake holders and the Engineers to take a decision on the required improvements in advance to reduce the accident expected to occur with the proposed improvements. With the Accident prediction in handy, it would be possible for arriving the cost of each improvement to make a decision in the improvements required for reducing the accidents in a project highway. This is an attempt to determine the required improvements in a project highway to be done in the recent future to reduce the accidents in the above stretch.

Keywords: Accident Prediction Model, Accident costing, Shoulder, Service Road, Linear Regression Analysis.

INTRODUCTION

Among all the types of transportation in India, Road Transport is the cheapest among them all. In addition to its economy, road transport is very flexible, easily accessible to all. Due to the above features, Road transport has earned preference among the transporters for transporting the heavy cargo in between two locations which are of short length. Due the economic and flexibility, road transport has become the higher share of both passenger and freight traffic among all other transport modes. Most of the vehicular traffic is using National highways only, which is only about 2% of Indian roads. Obviously, there is an increase in Accident rate in National Highways. So, there is urgent need for improvements of the existing National Highways network, on which Government of India is committed for the same by making lot of improvements program by up gradation of the existing road network. National Highways Authority of India is created by Government of India. The above improvement is not restricted only to National Highways but also to all other roads by various schemes such as CRIDP, CRF and PMGSY Schemes through concerned state Governments. In spite of the above improvements, the increase in Accident growth rate in India is phenomenal. Now a days, any improvements in India is being done based on the traffic only. Even then, accidents are happening which are due to various reasons.

Road Accidents a Major Concern

Earlier, Planning Commission had estimated that the total number of Fatal Accident deaths in year 2015 would be 154600. Now, Ministry of Road Transport has declared the fatal accidents for the year in 2015 and it is unbelievable that the same is more than the one predicted one by Planning Commission earlier. Do Indian Roads have become killer roads? The main culprit for the same is due to the greater operating speed of the high speed vehicles in Indian highways. In India, National Highways & Expressways are being designed for a design speed of 100 Kilometer per hour & 120 Kilometer per hour respectively. But no vehicle is lying at the above speed and in fact almost 30 to 40% more than the deign speed. In addition to the above, wrong side driving, no lane discipline, non adoption of the traffic rules etc are adding to the woes. The reason for the same is due to the speed of the vehicles which are cruising at a speed higher than the design speed.

Accidents in a highway could not be quantified to a single reason only. The main reasons causing an Accident are broadly classified as fault of driver, fault of vehicle, climate factors, Psychological condition of the driver and road condition. As already discussed, the reasons could not be quantified to a single factor and it may be due to one or combination of one or more reasons. Efforts for reducing the same could be reduced by three E's namely Education, Enforcement & Education. Education, Enforcement & Engineering measures on road safety aspects would be very helpful in reducing the accidents due to fault of driver, fault of vehicle and road condition respectively. It would not be possible to quantify the reasons for the accidents due to fault of the driver and the vehicle. However, the deficiencies in the road could be quantified with the proposed engineering measures.

As such, it would be possible to measure accidents in terms of the various parameters which are likely to cause accidents in a project highway. By giving weight age to

the different factors based on the existing condition, the number of accidents expected to occur in a project highway could be quantified.

Literature Review

Accident Prediction Model was developed for two lane undivided highways by Dr A. Veeraragavan, Department of Civil Engineering, IIT, Chennai & RR Dinu, Doctoral Research Student, Department of Civil Engineering, IIT, Chennai during 2011. Dr Rokade S Singh, Katiyar S.K. and Gupta S of Maulana Azad National Institute of Technology, Bhopal have developed Accident Prediction model for Ahemedabad City. Development of Accident Prediction Model for High Speed Corridors in India by Dr S. Nagan, Dr T.Baskaran & G.Athipathi in Proceedings of 2015 Global Conference on Communication Technologies(GCCT 2015). Safety Effects of Using Narrow Lanes and Shoulder-Use Lanes to Increase the Capacity of Urban Freeways published by US Department of Transportation.

METHODOLOGY

Accidents are expected to occur on account of Engineering details may be due to the various engineering parameters such as lane width, number of lanes, existing Vehicular traffic, traffic signs, presence of traffic signals, Illumination of junctions & built up area with street lights, average speed of vehicle in advert to the design speed in which the road is built and fencing. Since, the Accident data collection is found to be done in a proper manner in the National Highways which are recently completed; it is decided to utilize the Accident prediction model developed for such sections in the state of Tamilnadu is used for prediction of the model. In addition to the above, the effect of vehicle growth rate in the increasing of accident growth rate is established based on the trends of vehicle growth rate in advert to the increasing growth rate of Accidents over a period of time by extrapolating the same in a graph using Microsoft Excel. Based on the above, the accidents expected to occur in the recent future could be predicted from which, the required improvements on a project highway could be arrived. From which, it would be possible to suggest the improvements required to be provided in the above period to ensure the minimum accident rate.

Accident Prediction

Efforts have been made by many Engineers for development of Accident Prediction model to determine the expected Accidents to occur as per the existing features of the road.

As discussed in the above paragraph, the accident prediction model developed for the National Highways will give the true effect of the factors.

Accident prediction model developed exclusively for the National Highways by Dr S. Nagan, Dr T. Baskaran & G. Athipathi in Proceedings of 2015 Global Conference on Communication Technologies (GCCT 2015) is proposed to be used for this evaluation. As per the above model, number of Accidents expected to occur will be the independent variable, which will be decided by the engineering features such as lane width, number of lanes, existing Vehicular traffic, traffic signs, presence of traffic signals, Illumination of junctions & built up area with street lights, average speed of vehicle in advert to the design speed in which the road is built and fencing in the above sections. The above features will be the dependent variables based on which the Accidents are expected to occur as independent variable. As we all are aware that there are many types of accidents such as Fatal, Grievous injury, Minor injury & Vehicle damages, with each one has its own effects on the Accidents. For the same, all the Accidents are converted to a single factor called Accident Severity Index, by multiplying the various types of accidents based on their severity. As per the above prediction model, the accident prediction model has been developed by regression analysis as detailed below:

ACCI= 0.512+ 37.32L+ 4.091M-0.09MW+0.781SB-58.5SW-41.40SR-3.46FP+ 116.2LT+ 28.39RC+ 0.012DS+18.8TS-1.39TSG+0.006TV-5.09MJ-0.22F.

In which Lane configuration L, Presence of Median M, Median Width MW, Safety Barrier in Median SB, Shoulder width/type SW, Service roads SR, Footpath FP, Lighting LT, Road Condition RC, Operating speed with respect to Design speed DS, Traffic signs adequacy TS, Traffic signals TSG, Traffic volume with respect to capacity of road TV, Safety in Major junctions MJ and Fencing F are as mentioned above.

Determination of Accident Growth Rate

Normally the traffic growth rate for finalizing any improvement is being made with the past trends of registered Vehicle growth rate, traffic projection with respect to Per Capita Domestic product and standards publication by Indian Roads Congress IRC 37. The relation between the Population Vs Year, NSDP Vs Year and PCDP Vs Year has been arrived as follows.

Table 1

Graph	Equation	Accuracy
Population Vs Year	$Y=1002.2 \times Year + 2 \times 10^{-6}$	100%
NSDP Vs Year	$Y=23671 \times Year + 5 \times 10^{-7}$	97.2%
PCDP Vs Year	$Y=3418.3 \times Year + 7 \times 10^{-6}$	97.23%

The traffic growth rate of non commercial vehicles such as Cars, two wheelers are dependent on the Per Capita domestic product whereas the traffic growth rates of Commercial vehicles are dependent on the Net State Domestic product.

Most of the vehicles running in the state are of non commercial type and hence, it is proposed to determine the traffic growth rate with respect to PCDP.

To extrapolate the traffic growth rate value with respect to PCDP, both the total vehicle population and PCDP are

plotted in a graph against its logarithmic value for determination of elastic values which can be used for extrapolation.

On perusal of the below model, it is observed that the accident rate could be determined from the model Y=0.2843 x Logarithmic value of PCDP + 6.3885.

From the above model, accident growth rate could be determined from the expected vehicle growth rate as per the recent trends in recorded over a period of 15 years.

Table 2

Graph	Equation	Variance R^2	Accuracy
Logarithmic value of Vehicle Population Vs PCDP	Y=1.1951 x Logarithmic value of PCDP + 3.5897	0.9315	93.15%
Logarithmic value of Vehicle Population Vs Accidents	Y=0.2843 x Logarithmic value of PCDP + 6.3885	0.9438	94.38%

Table 3

Details	Types of Variables	Notation of Variables	Value Adopted in 2011
No of lanes in each direction	L	X1	4
Presence of Median	M	X2	4
Median Width	MW	X3	5
Presence of barrier if any if the median width less than 1.20 m	SB	X4	2
Shoulder width	SW	X5	3
Service Road	SR	X6	1.5
Raised foot path for Pedestrians	FP	X7	1
Lighting	LT	X8	5
Rood Condition	RC	X9	4
Design Speed	DS	X10	4
Traffic signs	TS	X11	2
Traffic signals in Major Junctions	TSG	X12	2
Traffic Volume	TV	X13	6
Major Junctions	MJ	X14	4
Fencing	F	X15	1
Accident Severity for no improvement	ACCI		664.5

Table 4

Year	Estimated Accident Growth Rate	Estimated no of accidents in Trichy Padalur section					Estimated Accident Severity Index
		Total	Fatal	Grievous Injury	Minor Injury	Vehicle Damage	
		Rate	5%	12%	43%	40%	
2012		1072	54	129	461	429	705.2688
2013	3.36	1108	55	133	476	443	728.9658
2014	3.36	1145	57	137	492	458	753.4591
2015	3.36	1184	59	142	509	473	778.7753
2016	3.36	1224	61	147	526	489	804.9422
2017	3.36	1265	63	152	544	506	831.9882
2018	3.36	1307	65	157	562	523	859.943
2019	3.25	1350	67	162	580	540	887.8912
2020	3.25	1393	70	167	599	557	916.7476
2021	3.25	1439	72	173	619	575	946.5419
2022	3.25	1485	74	178	639	594	977.3045
2023	3.13	1532	77	184	659	613	1007.894
2024	3.13	1580	79	190	679	632	1039.441
2025	3.13	1629	81	196	701	652	1071.976

Table 5

Year	Total	Fatal	Grievous Injury	Minor Injury	Vehicle damage	Accident Severity Index
			17%	43%	40 %	
2012	1072	0	182	461	429	410.4688
2013	1108	0	188	476	443	424.2606
2014	1145	0	195	492	458	438.5157
2015	1184	0	201	509	473	453.2498
2016	1224	0	208	526	489	468.479
2017	1265	0	215	544	506	484.2199
2018	1307	0	222	562	523	500.4897
2019	1350	0	229	580	540	516.7556
2020	1393	0	237	599	557	533.5502
2021	1439	0	245	619	575	550.8906
2022	1485	0	253	639	594	568.7945
2023	1532	0	260	659	613	586.5978
2024	1580	0	269	679	632	604.9583
2025	1629	0	277	701	652	623.8935

Table 6

Details	Value Adopted in 2011	Value to be Adopted in 2020 for no improvements	Value to be Adopted in 2020
No of lanes in each direction	4	4	4
Presence of Median	4	4	4
Median Width	5	5	5
Presence of barrier if any if the median width less than 1.20 m	2	2	2
Shoulder width	3	3	4
Service Road	1.5	1.5	2.5
Raised foot path for Pedestrians	1	1	1
Lighting	5	5	5
Rood Condition	4	4	4
Design Speed	4	4	4
Traffic signs	2	2	2
Traffic signals in Major Junctions	2	2	2
Traffic Volume	6	6	6
Major Junctions	4	4	4
Fencing	1	1	1
Accident Severity for no improvement	664.5	1078.527	2311.656
Desired Accident Severity	664.5	533.5502	0
Total no of accidents as per Model	637.7663	637.7663	537.9243

Determination of Accidents Expected to Occur

With the above Accident Prediction Model, it has been decided to give suitable weight age for each and every dependent variable to determine the accidents expected to occur during the year of construction. The weight age for dependent variables shall be fixed in such a way that the variables are adopted based on the existing features of the project highway. For the evaluation purpose, it has been proposed to analyze the stretch from Trichy Padalur section of NH 45, where the work was completed by the year in 2011 and the accident data and the model was evaluated for the accident predicted during the year 2011 along with the values adopted for the determination of the same is detailed in Table 3.

Now, the accident rate in the above project Highway could be determined from the model Y=0.2843 x Logarithmic value of PCDP + 6.3885 as mentioned in the paragraph V. Simultaneously, the history of proportion of the various types of the Accidents in the above project highway are also worked out and the same are 5%, 12%, 43% & 40% for Fatal Accidents, Grievous injuries, Minor injuries and Vehicle damages respectively. As already mentioned, each type of the accidents have its own type of impact on the economy of any country.

There are no specific cost of each type of the accidents in India and as such, the value prepared by Indian Roads Congress has been projected to the year 2011 based on the Whole Sale Price Index. As per the above, the price of Accident Costing would be Rs 6.5 lakhs, 1.00 Lakh, 0.03 Lakh and 0.50 Lakh for Fatal, Grievous injuries, Minor Injuries & Vehicle damages respectively. Based on the above, the expected vehicle growth rate along with the expected Accident Growth rate has been determined using the above equation and the same is detailed in Table 4.

As per the calculations regarding the Accident costing, the effect of the fatal accidents would have a more adverse effect on the impact of the economy. The price of Accident Costing would be Rs 6.5 lakhs, 1.00 Lakh, 0.03 Lakh and 0.50 Lakh for Fatal, Grievous injuries, Minor Injuries & Vehicle damages respectively. It has been proposed to aim at “Zero fatality” since the same is expected worldwide nowadays which is in line with the “Vision Zero” concept.

As Expected number of Fatal accidents expected to occur shall be zero and the same is added in the Grievous Injuries column as such. As per the Accident costing mentioned above, the revised share of total number of Accidents are 0%, 17%, 43% & 40% for Fatal Accidents, Grievous injuries, Minor injuries and Vehicle damages respectively. Based on the above, the desired expected accidents desired are arrived with the equation for determining the accidents desired to occur with zero fatuities are as given in Table 5.

On perusal of the Table 4 and Table 5, it is observed that the accident severity is getting reduced phenomenally with the reduction in number of fatal accidents, which is the desired result and the aim of this paper towards Zero fatality.

Determination of Improvements Required

Now, the Expected desired Accident severity expected to occur for the year 2020 is about 533.55.

With the desired Accident severity, the variables which contributes to the most of the accidents are evaluated with respect to the site conditions and a suitable weight age is given for the proposed improvements in such a way that the desired expected Accident Severity Index is brought somewhere around 533.55.

As such, the weight age for the variables in the Accident Prediction model as mentioned in the Paragraph V for the above stretch has been modified to the extent in such a way that the Accident Severity is brought somewhere around the desired results.

The above modifications are made and tabulated as detailed in Table 6.

On Perusal of the table no 6, it is observed that by making modification in Service roads and shoulder width, the Accident Severity Index could be brought down to 533.9243 with the desired one is 533.55.

The value of the service road & shoulder width are changed to 2.5 and 4 respectively for the year 2020 with the same was about 1.5 & 3 for service road & shoulder respectively for the year 2011.

The standard width of the same varies from 1.50 m to 1.875 m depending upon the classification of the road. Normally, the shoulders are made of earth or gravel. Sometimes, the same may strengthened by stones which are called as Hard Shoulders or by black topping which is called as Paved shoulders to increase the capacity of the road n urban areas. Improvements to the shoulder could be made by increasing the width of the shoulder to a width of standard one by adding an extra width than the normal. Or the shoulders may be improved by Hard shoulders namely hard stones are fixed in the soft earthen shoulders to improve the efficiency and carrying capacity of the shoulders. As per the table 6, the condition of the shoulder width may be required to be improved by 25% to bring down the fatal accident to nil.

Service roads are a part of highway constructed parallel to the man highway, constructed with the objective to segregate the local traffic from the main highway for the safety of the road commuters. The normal width of the service road would be minimum of 3.50 m to 7.50 m with a minimum of 5.50 m if the same is executed to cater two traffic in urban reach.

The service road will be of same composition of main highway, which will be connected to the main carriageway by proper acceleration & deceleration lane for safety of road users.

As per the above, the length of the existing service road may be required to be increased up to 50% of the length on the year 2011.

RESULTS AND DISCUSSION

1. Accidents rate can be kept under control till next improvement proposal in a highway by doing improvements to the existing features of the road.
2. The impact of Shoulders width & Service roads play a key role in reduction of the accidents.
3. The concept of availability of the usable shoulder in the available shoulder width needs to be broadly examined. The above action will reduce the number of accidents due to rear end collision which is common in the high speed corridors since the vehicle are parked in the carriageway due to non availability of the shoulders/shoulders of minimum width only. As such, Shoulder width may be increased to 2.50 m from 1.50.
4. Paved shoulders width of 1.5 m available in the main carriageway shall be reserved for two wheelers only. This will encourage the two wheelers to stay away from the main carriageway.
5. Provisions should be made for widening of the shoulder to paved shoulders for a width of 3.50 m every one Km to park the vehicle in the event of break down to avoid rear end collision which has become a common scene in most of High speed corridors, nowadays.
6. Service road shall be invariably provided continuously in all built up areas, bridges, railway over bridges and merging of the same with main carriageway shall be with proper acceleration & deceleration lane for safety of commuters.
7. Facilities must be provided for vulnerable road users such as exclusive bicycle track, raised platforms, exclusive parking spaces on all urban arterial roads and traffic calming techniques on all roads.
8. Implementation of Intelligent Transport System (ITS) to be effected in high speed corridors.

Limitations and Scope of Further Study

The limitations of the above way of predicting the Accident rates are as below:

1. As per the model developed, the reasons for the accidents are confined to the road features only. However, we could not blame the road for its fault by the road users' even though the reason or the accident may be due to their fault or the fault of the vehicle. As such, we may provide an improvement which may be more than that of required one.
2. Accident prediction model could not address about the heterogeneous type ranging from high speed SUVs to small LCVs & animal drawn vehicles.
3. Driver fault, Vehicle Fault & Climatic conditions could not be addressed in this model which are the major cause for the accidents in a country like India.
4. Moreover, the model needs to be revised every five year to have precision of the desired results.
5. The prediction may vary since the proposed results are based on the WPI index of the country. If there is a sudden raise or surge in the economy of India, this model may not work.
6. Suggested Improvements could be proposed by a professional engineer who is well acquainted with the site conditions and the details of the accident happened in the recent past.
7. The collection of accident data needs to be more precise so that the required improvements can be taken up on the priority basis, which require s a continuous monitoring of the project highway, for which ITS would be proper usage so that all the accident data could be collected using GPS coordinates.

Considering the above facts, the scope of further study on the above are as detailed below:

1. Accident Prediction model shall be developed for each section of National Highways to have more accuracy.
2. ITS needs to be effectively used and the data collection pertaining to the accidents shall be with GPS coordinates so that a decision could be taken by stake holders & engineers.

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