

# Road Accidents Study Based on Regression Model: a Case Study of Vijayawada city to Hanuman Junction

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**ABSTRACT:** The Paper discusses the development of an accident prediction model based on regression analysis. It is attempted to develop accident model. Vijayawada city is taken as case study. The data set which is mainly fatal accidents and total accidents for Vijayawada city is brought from "Traffic Police Department". Accident data are related to hourly classified traffic volume per lane extracted from classified traffic volume count survey of Vijayawada city. A liner regression model is developed in this study exhibits satisfactory goodness-of-fit and prediction success rate.

**Keywords:** accidents, regression, survey.

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## I. INTRODUCTION

A traffic collision, also called a motor vehicle collision (MVC) among other terms, occurs when a vehicle collides with another vehicle, pedestrian, animal, road debris, or other stationary obstruction, such as a tree, pole or building. Traffic collisions often result in injury, death, and property damage. A number of factors contribute to the risk of collision, including vehicle design, speed of operation, road design, road environment, and driver skill, impairment due to alcohol or drugs, and behaviour, notably speeding and street racing. Worldwide, motor vehicle collisions lead to death and disability as well as financial costs to both society and the individuals involved.

In 2013, 54 million people sustained injuries from traffic collisions. This resulted in 1.4 million deaths in 2013, up from 1.1 million deaths in 1990. About 68,000 of these occurred in children less than five years old. Almost all high-income countries have decreasing death rates, while the majority of low-income countries have increasing death rates due to traffic collisions. Middle-income countries have the highest rate with 20 deaths per 100,000 inhabitants, 80% of all road fatalities by only 52% of all vehicles. While the death rate in Africa is the highest (24.1 per 100,000 inhabitants), the lowest rate is to be found in Europe (10.3 per 100,000 inhabitants).

Traffic collisions can be classified by general type. Types of collision include head-on, road departure, rear-end, side collisions, and rollovers. Many different terms are commonly used to describe vehicle collisions. The World Health Organization use the term road traffic injury, while the U.S. Census Bureau uses the term motor vehicle accidents (MVA), and Transport Canada uses the term "motor vehicle traffic collision" (MVTC). Other common terms include auto accident, car accident, car crash, car smash, car wreck, motor vehicle collision(MVC), personal injury collision (PIC), road accident, road traffic accident (RTA), road traffic collision (RTC), and road traffic incident (RTI) as well as more unofficial terms including smash-up, pile-up, and fender bender.

Some organizations have begun to avoid the term "accident". Although auto collisions are rare in terms of the number of vehicles on the road and the distance they travel, addressing the contributing factors can reduce their likelihood. For example, proper signage can decrease driver error and thereby reduce crash frequency by a third or more. That is why these organizations prefer the term "collision" to "accident". In the UK the term "incident" is displacing "accident" in official and quasi-official use. Historically in the United States, use of terms other than

"accidents" had been criticized for holding back safety improvements, based on the idea that a culture of blame may discourage the involved parties from fully disclosing the facts, and thus frustrate attempts to address the real root causes.

### **TYPES OF TRAFFIC COUNT**

Traffic Data Collection and projections thereof of traffic volumes are basic requirements for planning of road development and management schemes. Traffic Data forms an integral part in the science of descriptive national economics and such knowledge is essential in drawing up a rational transport policy for movement of passengers and goods by both government and the private sectors.

#### **MANUAL COUNTS**

The most common method of collecting traffic flow data is the manual method, which consists of assigning a person to record traffic as it passes. This method of data collection can be expensive in terms of manpower, but it is nonetheless necessary in most cases where vehicles are to be classified with a number of movements recorded separately, such as at intersections.

At intersection sites, the traffic on each arm should be counted and recorded separately for each movement. It is of paramount importance that traffic on roads with more than one lane are counted and classified by direction of traffic flow.

#### **AUTOMATIC COUNTS**

The detection of vehicular presence and road occupancies has historically been performed primarily on or near the surface of the road. The exploitation of new electromagnetic spectra and wireless communication media in recent year, has allowed traffic detection to occur in a non-intrusive fashion, at locations above or to the side of the roadway. Pavement-based traffic detection currently relatively inexpensive, will be met with fierce competition in the coming years from detectors that are liberated from the road surface.

The most commonly used detector types are:

- i. Pneumatic tubes
- ii. Inductive loops
- iii. Weigh-in-Motion Sensor types.
- iv. Micro-millimetre wave Radar detectors.
- v. Video Camera.

## **II. MOTIVATION**

### **RESOURCES REQUIRED FOR COLLECTION OF TRAFFIC DATA**

Assessment of available resources prior to commencement of any activity is critical to any assignment at hand. For traffic data collection, it is important that proper assessment of the extent or scope of the envisaged counting (quality level of data required) is undertaken. This is aimed at ensuring that the planned and organised exercise is achieved at optimal cost and with the expected accuracy. The exact number of persons and equipment to undertake a specific traffic counting assignment is dependent, among others, on

- The location of the station.
- The quality of data to be collected
- The level of traffic flow.
- The nature of the road section and traffic flow characteristics within which the station falls
- Traffic composition.

#### **Equipment Requirement**

### **Automatic Traffic Counting Equipment**

Although a detailed discussion of the various types of automatic traffic counter equipment and systems was dealt with in Chapter 2.0 the main aim of this part is to sight typical equipment required for traffic data collection. In essence, typical automatic traffic data collection equipment consists of a detector to detect vehicles and a counter to record the information.

## **TRAFFIC AND SITE SAFETY**

Traffic safety during the conduct of traffic surveys is mandatory and is the responsibility of the institution or body undertaking the surveys. The Road Traffic Act Cap 69:01 places a statutory responsibility in ensuring that appropriate safety measures are in place before a survey can be conducted on a road

1 Site Safety

2 Site Markings

### **TRAFFIC COUNTING PROCEDURE**

The result of traffic counting is subject to sampling error and observational uncertainty. Sampling error in traffic counting is error emanating from collected traffic data while observational error relates to vehicle classification by vehicle types resulting in some vehicles being wrongly classified. In this context, vehicle classification cannot be defined without ambiguity and therefore is a subject of enumerators' interpretation of the passing traffic Stream. To minimise the error, statistical methods are more preferable to use for analysis to smooth out sampling and observational errors.

### **Factors Affecting Vehicle Counting**

There are many factors that affect traffic counting and the most common includes

- Weather conditions.
- Purpose of the traffic counting
- Method of traffic counting
- Location of the counting sites
- Traffic flow level
- Road type
- Traffic composition

### **Counting Accuracy and Quality Assurance**

Quality of sampled data largely depends on, among others, the method followed in the establishment, use and maintenance of the count stations. For automatic counts equipment, close co-operation with the manufacturer is necessary in order to achieve maximum benefits. The operation procedures should be clearly written and detailed for easy understanding by both the client and the supplier

### **Duration of Counting**

Duration of traffic counts is dependent on the type and quality of data required. Depending on the end use of traffic data being collected, counts at established permanent stations are ideally conducted over 12, 16 and 24 hours continuously for at least seven consecutive days per station. The selection of counts duration will depend on whether the amount of data collected will produce reliable results. This decision will depend on the characteristics of the traffic flow and the type data required for a particular location or project. Typical duration are given in Table as shown earlier in this guideline

Scenario	Urban	Inter-urban	ecreation
High	.016	.115	.27
Medium	.000	.060	.14
Low	0.989	.016	0.96

### Counting Procedures

- 1 Intersection
- 2 Straight Roads
- 3 Urban Roads
- 4 Rural Roads
- 5 Dual Carriageways

### TYPICAL CONVERSION OF TRAFFIC COUNT

Main input parameters for design of the road are the Annual Average Daily Traffic (AADT) and the cumulative loading over the design life of the road (normally 20 years), that is the number of vehicles passing a point in both directions per day taking into account the variation in the traffic flow throughout the year and the total number of axles for the same traffic volume. Determination of the AADT from 12-hour traffic count is achieved by converting to 16-hour flow (the volume of traffic flow counted in hours) by using applicable conversion factors. Having obtained the 16-hour counts, a further conversion to 24-hour flow may be carried out to obtain an Average Daily Traffic flow, and subsequently to Annual Average Daily Traffic. For illustration, the following conversion actors have been used in the calculations

Where:

$AADT = T\text{-}ADT / 365$

AADT= Average Annual Daily Traffic.

T-ADT= Total Average Daily Traffic

Conversion of Peak Hour Traffic to Average Daily Traffic (ADT) Peak hour traffic used for design is the traffic, which passes a point during the severest peak hour(s) of the counting period. In order to convert peak hour traffic to Average Daily Traffic (ADT), the peak hour traffic should first be converted to 12 hour or 16-hour traffic flow and then to 24-hour traffic flow. For instance, if peak hour flow is 10% of 16-hour counts, then for any given number of vehicles, ADT is given by the following:

$$\begin{aligned} \text{Peak hour flow} * \text{Conversion factor} &= \text{ADT (16-hour)} \\ \text{Then, ADT (16-hour)} * \text{Conversion factor} &= \text{ADT (24-hour)} \end{aligned}$$

The conversion factor is the proportion of traffic flow over a given peak time as it relates to that prevailing traffic counted under same traffic conditions and over a specific counting period Conversion of Day Time Traffic to Average Daily Traffic. In order to convert Day Time Traffic to Average Daily Traffic and subsequently to Annual Average Daily Traffic, derived factors based on the duration of counts shall be used. For the purpose of illustration the following has been assumed:

Seven (7) day counts is conducted on a busy rural main road.

Constant 16-hour traffic flow counts from Monday to Friday of 10 000 vehicles each has been obtained

A further 16-hour constant traffic flow for Saturday and Sunday of 8 000 vehicles each was also obtained

$$\text{Calculation-day 16 hour traffic flow} = (5 \times 10\,000) + (2 \times 8\,000) = 66,000 \text{ vehicles}$$

Using a 95% confidence limit for the 24-hour traffic flow with 5% tolerance.

Then, 16-hour traffic flow is 95% of 24-hour traffic flow, therefore;

7 days 24 hour traffic flow =  $66\,000 / 0.95 = 69\,474$  vehicles

Average Daily Traffic (ADT) =  $69\,474 / 7 = 9925$  vehicles

As for the Annual Average Daily Traffic (AADT), the derived Day Traffics converted as follows:

AADT =  $9925 \times \text{conversion factor}$   
 =  $9925 \times 1.141$  (considering medium scenario)  
 = 11 324 vehicles

### ANALYSES AND PRESENTATION OF TRAFFIC DATA

Analysis of traffic data will vary greatly in complexity depending on the scope and objective of the survey. At the simplest extreme, analysis consists of totaling different categories of vehicles in a volumetric count. At the other extreme, complex surveys may require computer analysis of traffic to journeys, allocation of existing and proposed road network, traffic projections and other related operations/analysis.

1 Layout of Analysis

2 Computer Analysis

3 Manual Analysis

4 Data Entry and Analysis

i. Data Entry

ii. Data Analysis

### III. DESIGN

#### FIELD AND LABORATORY INVESTIGATION

1 Dynamic Cone Penetration Test

2 In-situ Moisture content

Field Moisture

	1+000	2+000	3+500
Moisture	18%	12%	6%

3 In-situ Density by Core Cutter method

Table 3.2: Core Cutter

	1+000	2+000	3+500
Water Content	18%	12%	6%
Dry Density	1.58	1.75	1.74

#### Laboratory Investigations

Laboratory Tests on Sub grade Soil, the sub grade must be able to support loads transmitted from the pavement structure. This load bearing capacity is often affected by degree of compaction, moisture content, and soil type. A sub grade that can support a high amount of loading without excessive deformation is considered good. Sub grade materials are typically characterized by their resistance to deformation under load, in other words, their stiffness or their bearing capacity, in other words, their strength. In general, the more resistant to deformation a sub grade is, the more loads it can support before reaching a critical deformation value.

So to evaluate the properties of the existing subgrade the laboratory tests conducted are as follows

- Grain Size Analysis
- Atterberg Limits
- Free Swell Index
- Compaction and Optimum Moisture Content
- California Bearing Ratio Test

#### BITUMINOUS MIX DESIGN:

### 1 Specific Gravity Test

**Specific Gravity of Various Binders**

Binder Type	VG-30
Sp. Gravity	1.03

### 2 Penetration Test

**Penetration values of Various Binders used in the Study**

Binder Type	VG-30
Penetration	61

### 3 Softening Point Test

**Table 4.5: Softening Point values of various Binders**

Binder Type	VG-30	CRMB-60
Softening Point	53	64

### Aggregate

**1 Aggregate Impact Test:** Aggregate impact value = 13%

### 2 Specific Gravity and Water Absorption

**Specific gravity and Water absorption results of aggregates**

Location	Size (mm)	Specific Gravity	Water Absorption (%)
Local Material	25	2.60	0.33
	20	2.64	0.41
	10	2.61	0.63
	Dust	2.47	1.7

**Bitumen Adhesion Test:** The aggregate Coating Value = 98%

### Shape Tests

**Test Results of Elongation and Flakiness of Aggregates**

Location	Size (mm)	Flakiness (%)	Elongation (%)	Combined Flakiness & Elongation Indices (%)
Local Materials	25	12.1	17.8	29.8
	20	9.4	34.3	43.7
	10	71.7	60	131.7

### RAP usage in the mix

Reclaimed asphalt pavement (RAP) is the term given to removed and/or processed materials containing asphalt and aggregates. These materials are generated when asphalt pavements are removed for construction, resurfacing, or to obtain access to buried utilities. When properly crushed and screened, RAP consists of high- quality, well-graded aggregates coated by asphalt cement.

The utilization of RAP is done in the DBM and WMM layers i.e in the granular layers. High RAP content mixes may pose special problems in terms of workability and compatibility. So the % of RAP to be used is limited to 15% in the DBM mix and to 35% in the WMM mix. Considering these % of RAP, the Marshall Mix design is prepared.

### Marshall Mix Design

#### Procedure

1. The coarse aggregates used for granular construction are normally of the sizes mm. The fractions from 4.75mm to 150 micron are termed as fine aggregates. The size 4.75mm is a common size appearing in both the fractions.
2. Grading pattern of aggregates—coarse, fine or combined—is determined by sieving a sample successively through all the sieves mounted one over the other in order of size, with the larger sieve on the top. The

material retained on each sieve after shaking, represents the fraction of aggregate coarser than the sieve in question and finer than the sieve above.

3. Sieve analysis gives the gradation and the fineness modulus which is an empirical factor obtained by adding the cumulative percentages of aggregates retained on each of the dividing standard sieves and dividing by 100. The larger the figure, the coarser will be the material.
4. Bring the sample to an air dry condition either by drying at room temperature or in oven at a temperature of 100°C to 110°C. Take the weight of the sample.
5. Clean all the sieves and sieve the sample successively on the appropriate sieve starting with the largest as shown in Fig 4.1.
6. Shake each sieve separately over a clean tray.
7. On completion of sieving, note down the weight of them at trial retained on each sieve.

<b>MARSHALL TEST PROPERTIES</b>					
<b>Bitumen %</b>	<b>3.5</b>	<b>4</b>	<b>4.5</b>	<b>5</b>	<b>5.5</b>
<b>Density</b>	2.33	2.35	2.371	2.383	2.372
<b>Max Specific Gravity</b>	2.508	2.481	2.472	2.454	2.436
<b>Va</b>	6.5	5.7	4.1	2.9	2.62
<b>VMA</b>	12.41	12.14	11.83	11.84	12.71
<b>VFB</b>	45.42	57.17	65.34	75.59	79.39
<b>Stability (Correction)</b>	880	962	1075	1006	933
<b>Flow in mm</b>	3	3.3	3.7	4	4.2

## PAVEMENT DESIGN:

### Design of Flexible Pavements

As discussed earlier the design of flexible pavements is done by using the guidelines of IRC 37: 2012

#### IRC 37:2012

Indian roads congress has specified the design procedures for flexible pavements based on CBR values. The Pavement designs given in the previous edition IRC:37-1984 were applicable to design traffic up to only 30 million standard axles (msa). The earlier code is empirical in nature which has limitations regarding applicability and extrapolation. These guidelines follow analytical designs and developed new set of designs up to 150 msa.

These guidelines will apply to design of flexible pavements for Expressway, National Highways, State Highways, Major District Roads, and other categories of roads. Flexible pavements are considered to include the pavements which have bituminous surfacing and granular base and sub-base courses conforming to IRC/ MOST standards. These guidelines apply to new pavements.

In M-E pavement design approach, the pavement is idealized as a layered structure (generally assumed as elastic for simplicity in analysis) consisting of three to four horizontal layers made up of bituminous surfacing, base, sub-base and the subgrade. Each layer is characterized by its elastic modulus, Poisson's ratio and the thickness. Fatigue, rutting and low temperature cracking are generally considered as the important modes of failure of a bituminous pavement structure.

Indian Roads Congress Method is based on an empirical method where the thickness value of a pavement used was read from the CBR value of the sub-grade. From the design chart the total pavement thickness could be read for a given CBR value and cumulative standard axle load.

In our design the pavement is divided into four layers i.e Bituminous course, WMM layer, DBM layer and Sub grade. So we need to analyse the properties of all these layers.

### Benkelman Beam Method:

This Method deals with the experimental investigation by using the Benkelman beam method, using this method we evaluate the max deflection that is occurring on the pavement at the regular intervals and hence we will design the overlay of the pavement. This test procedure covers the determination of the rebound deflection of a pavement under a standard wheel load and tyre pressure, with or without temperature measurements.

### Equipments:

The basic components or equipments required are as follows

1. A Benkelman beam to the ministry of works and development pattern having the dimensions shown in the figure. The beam must be fitted with a satisfactory locking device designed to secure the beam when moving to a new site and a suitable vibrator mounted at the pivot point.  
In sunny whether the beam may pass from shade into sunshine as the vehicle moves away .Therefore a shield similar to that described in Road Research Unit New letter No49 should be used.
2. A Truck or Tractor with an axial load of 8.2  $\pm$  0.15 Tones equally distributed on the two dual tyre wheels operating at the inflation pressure necessary to give tyre contact area of 0.048 $\pm$ 0.0002m<sup>2</sup>. The tyre shall be 10.00 x 20,12 ply with tubes and rib treads.
3. A tyre pressure gauge graduated in 20Kpa divisions or smaller.
4. A thermometer with a range of 0-6<sup>0</sup> in 1<sup>0</sup>C divisions.
5. A mandrel suitable for making a 1000mm deep hole in the pavement for inserting the thermometer. The diameter of the hole should be 13mm.
6. A can containing either glycerol or oil for filling the thermometer hole.

## IV. RESULT

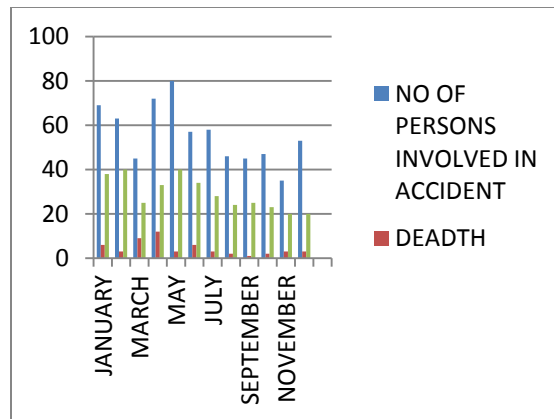
### DATA COLLECTION

This deals with the complete data collection of traffic data, accident data and the other required date which is used for the computation of traffic model.

#### ACCIDENT DATA COLLECTION

MONTH	NO OF ACCIDENTS
JANUARY	46
FEBRUARY	44
MARCH	24
APRIL	48
MAY	51
JUNE	40
JULY	38
AUGUST	28
SEPTEMBER	28
OCTOBER	31
NOVEMBER	25
DECEMBER	33





MONTH	NO OF ACCIDENTS	TWO WHEELERS	CARS	BUS AND LORRIES	TRACTORS	AUTO
JANUARY	46	22	12	2	2	8
FEBRUARY	44	28	9	3	2	6
MARCH	24	6	6	5	0	2
APRIL	48	25	9	2	4	3
MAY	51	24	10	4	2	4
JUNE	40	18	12	3	1	2
JULY	38	20	8	8	0	1
AUGUST	28	15	11	5	2	3
SEPTEMBER	28	24	9	3	0	2
OCTOBER	31	19	5	5	3	1
NOVEMBER	25	10	9	3	1	0
DECEMBER	33	22	15	4	2	3

### R<sup>2</sup> Values of Variables

S.No	Variable (X)	Expression	Relationship	R <sup>2</sup>
1	INJURIES	$Y=0.0024X^3+0.1483X^2-2.3587X+19.481$	POLYNOMIAL	0.7007
2	DEATH	$Y=0.0959X^3+1.1919X^2-2.993X+14.431$	POLYNOMIAL	0.5021
3	2W	$Y=0.0601X^2+1.7711X-7.68$	POLYNOMIAL	0.7039
4	AUTO	$Y=0.0695X^3+1.2273X^2-5.8668X+20.245$	POLYNOMIAL	0.3262
5	LORRY	$Y=1.8833X^3+10.5X^2-16.217X+20$	POLYNOMIAL	0.2499
6	TRACTOR	$Y=0.8833X^2-3.5X+16.867$	POLYNOMIAL	0.0534
7	CAR	$Y=1.5833X^3+8.25X^2-7.6667X+19.481$	POLYNOMIAL	0.6169

### Multiple Linear Regression Analysis

Multiple Regression analysis (MLR) is a system for examining the relationship of a collection of independent variables to a single dependent variable. Multiple linear regression analysis was one of the first and simple methods of analysis taken into consideration for the model development, which gave satisfactory performance. This technique is still being used in the development of simple models. The data used for the model development of no of

accidents per year is

No of Accidents(Y)	INJURIES(X1)	DEATHS(X2)	2W(X3)	CAR(X4)
46	25	6	22	12
44	20	3	28	9
24	11	9	6	6
48	27	12	25	9
51	37	3	24	10
40	17	6	18	12
38	27	3	20	8
28	20	2	15	11
28	19	1	24	9
31	22	2	19	5
25	12	3	10	9
33	30	3	22	15

From the matrix v

$$a_0=43.60122582$$

$$a_1=0.010192044$$

$$a_2=7.23865E-13$$

$$a_3=0.008516712$$

$$a_4=3.26086E-07$$

### Accident Prediction Model

We develop an accident prediction model for the road length which we have selected by using linear regression analysis. The primary objective of the study was to develop a model to predict any future accidents. For this study, we considered the variables like injuries, deaths and type of vehicles. Road width is not considered since the width is same along the stretch. The accident prediction model developed is as given below:

$$Y_g = a_0 + a_1 X_1^2 + a_2 X_2^2 + a_3 X_3^2 + a_4 X_4^2$$

Y	$Y_g$	SSR	SSE
46	9.666667	711.1109333	1320.111
44	7.666667	821.7777778	1320.111
24	-12.33333	2368.4412	1320.111
48	11.66667	608.4428	1320.111
51	14.66667	469.443	1320.111
40	3.666667	1067.108933	1320.111
38	1.666667	1201.775467	1320.111
28	-8.33333	1995.108133	1320.111
28	-8.33333	1995.108133	1320.111
31	-5.33333	1736.108333	1320.111
25	-11.3333	2272.107933	1320.111
33	-3.33333	1573.4418	1320.111
		16819.97444	15841.33

Y = No of Accidents Occurred

$Y_g$  = Generated Accidents

SSR = Sum of Squares of Regression

SSE = Sum of Squares of Error

SST = Total Sum of Squares

SSR = 16819.97444

SSE = 15841.33

SST = SSR + SSE = 32661.30778

$R^2$  = Co-efficient of Determination = SSR/SST = 1.061778

## V. CONCLUSION

Accident Prediction Model is developed using Multiple Linear Regression Analysis for this part of roads is based on the factors influencing road accidents. The dependent variable used in the model is Number of Accidents (Y). The independent variables used in the model are:

1. Injuries ( $X_1$ )
2. Deaths ( $X_2$ )
3. Two Wheelers ( $X_3$ )
4. Cars ( $X_4$ )

The model development in the research using the above variables is:

$$Y_g = a_0 + a_1 X_1^2 + a_2 X_2^2 + a_3 X_3^2 + a_4 X_4^2$$

The Coefficient of Determination ( $R^2$ ) obtained is 0.514982

Accident data from different police station suggests that there is a lack of proper enforcement and education to roadway safety. These weakness can be minimized through comprehensive corrective measures. Local community initiatives to improve the conditions are very sparse. Importantly, such efforts would require considerable resources particularly trained local personnel, safety specialists and researchers so as to build up indigenous capacity and attain sustainable safety program.

It is suggested to further refine the model reported in this study using more number of variables to get a more realistic picture in the predicting or forecasting accidents, though accidents occurrence is random phenomenon and therefore we can not exactly predict future trends by using any model or theory, but it is a very handy tool in the hands of planners and decision makers to take remedial measures in advance by studying future trends using such models, to take mitigation measures to minimize the accident rate to certain extent and to take other safety measures.

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