ACCIDENT ANALYSIS AND DEVELOPMENT OF CRASH PREDICTION MODEL FOR A MID-SIZED CITY

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BY

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CERTIFICATE

This is to certify that the project entitled "Accident analysis and development of crash prediction model of mid size city" presented by Swagat Chandan Nayak as a prerequisite for the grant of Bachelor Of Technology Degree in Civil Engineering at National Institute of Technology, Rourkela is a true work completed by him under my supervision and direction. To the best of my learning the matter epitomized in this report has not been submitted in any school/institute for awarding degree or diploma.

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ABSTRACT

Accident analysis studies aim at the identification of high rate accident location, safety deficient areas and the accidents prone zones within Rourkela city, using GIS. For this purpose the road accident data for seven consecutive years, pertaining to Rourkela city has to be used.

Accident particulars like year, location, type of vehicle involved, are included in GIS database. The buffer function available in the spatial analyst extension of Arc GIS software was to be applied to identify the accident prone areas in Rourkela. The road geometry will be measured in accident prone location to find out the cause of accident, based on these result, suggestion are to be provided to reduce the frequency of accidents at that particular place.

Accidents prediction is done by regressing traffic volume with accident data to obtain an equation which could apprehend the forth coming accidents in the future.

Preventive measures regarding the improvement of traffic condition for minimizing accidents rate are suggested.

CHAPTER 1

1.1 INTRODUCTION:

The transportation issues confronted by different urban areas requires hunt of strategies or choices that guarantee productive, protected, attainable and quicker method for transport. It has been assessed that India at present records for almost 10% of way accident fatalities word wide in excess of 1300000 persons are genuinely harmed on the Indian street consistently every year ; thus movement security has turned into a real range of concern. The advancement of urban transport has not kept pace with the traffic both regarding quality and amount, as a consequence of which the utilization of customized transport principally bikes and moderate open transport is developing at a quick rate. The lopsided development of traffic along road length, with unapproved infringements on road space, absence of traffic and lane discipline and inadequacies in traffic control have promoted the expanding issues of congestion in urban regions. The progressions in GIS and GPS might be put to viable use for effective use in accident analysis. Although GIS has been used for over twenty years however it has only been recently used in the field of Transportation. In addition to promoting linkage between various types of data and maps GIS is able to manipulate and visually display numerous types of data for easy comprehension. GIS is a Technology for managing and processing locational and related information. It visually displays the results of analyses thus enabling sophisticated analysis and quick decision making. Development of a system that

uses GIS to analyse traffic accidents has been pursued towards improving the efficiency and effectiveness of traffic accident countermeasures. Also GIS would make analysis less time consuming and less tedious which otherwise would become very labour sensitive. Thus GIS will offer a platform to maintain and update accident record database and use it for further analysis.

1.2 GIS POTENTIALTY:

GIS is Geographical Information framework that supports the display of spatial data. GIS has its quality in giving proficiencies to model the physical nearness of spatial characteristics. The effective part of GIS is the adaptability in displaying spatial articles to suit specific application prerequisite. It gives proficiencies to store and keep up expansive data sets. GIS gives social connection between diverse streams of accident data. GIS empowers the safety experts to look at accidents along a road way segment with land use and zoning data or population and other demographic data to increase a finer understanding of the relationship of crash incidents or the zone-data that could be incorporated with accidents records to give a genuine picture. Visual capability of GIS grants the mapping of FIR data and geometry data.

CHAPTER 2

2.1 LITERATURE REVIEW:

GIS permits users to display information geographically. It can also provide a common link between two or more previously unrelated databases. The most useful aspect of GIS as a management tool is its ability to associate spatial Objects (street names, milepost, route number, etc.) with attribute information (accidents, cause, etc.). Most of the documents reviewed consider the use of GIS in transportation under either for general data maintenance or for simple data analysis. A few studies depict how GIS help in the integration of many transportation elements

Meyer and Sarasua (1996) envisioned a common and coordinated database system that will serve all aspects of transportation management such as congestion, pavement, bridges, safety, inter-modal activities, and public transportation.

Martin (1993) did a similar study, in which he proves that incorporating GIS in a pavement management program improves the reporting and analysis of data through the production of maps and graphic displays.

Affum and Taylor (1996) described the development of a safety Evaluation Method for a Local Area Traffic Management (SELATM), which is a GIS based program for analyzing accident patterns over time and the evaluation of the safety benefits.

GIS can also be implemented in determining roadway and surface conditions. This was proven by **Gharaibeh et.** Al. (1994) when they proposed to use GIS to obtain statistical and spatial analyses of roadway characteristics such as safety, congestion level and pavement conditions.

In a separate study by **Johnson and Demetsky** (1994), the capabilities of GIS in providing a framework for a management system were proven once again. It highlighted the fact that many transportation analysts reap benefits from improved access to data. Establishment of the geographic referencing scheme is the major contributor in making data more readily available.

Faghri and Raman (1995) developed a GIS-based traffic accident information system for Kent County, Delaware. Their system included knowledge about the occurrence of crashes, such as conditions of incident site, and frequency of incidents at any given location (mile-point) on a roadway.

Ogunbodede E. F. explained that GIS is a tool that can be used to sustain an endurable flow of traffic in urban environment, provided it is built on a properly designed database, which must also be amenable to constant updating.

Ammar Alazab, Sitalakshmi Venkatraman, Jemal Abawajy, and Mamoun Alazab examined the value of real-time traffic information gathered through Geographic Information System for achieving an optimal vehicle routing within a dynamically stochastic transportation network.

Mukti Advani,B.Srirama and S.K.Pathan developed a GIS based model with an objective of minimizing travel distance and travel time of users. Constrains taken into consideration were impedance for intersections, type of road and speed.

CHAPTER 3

METHODOLOGY:

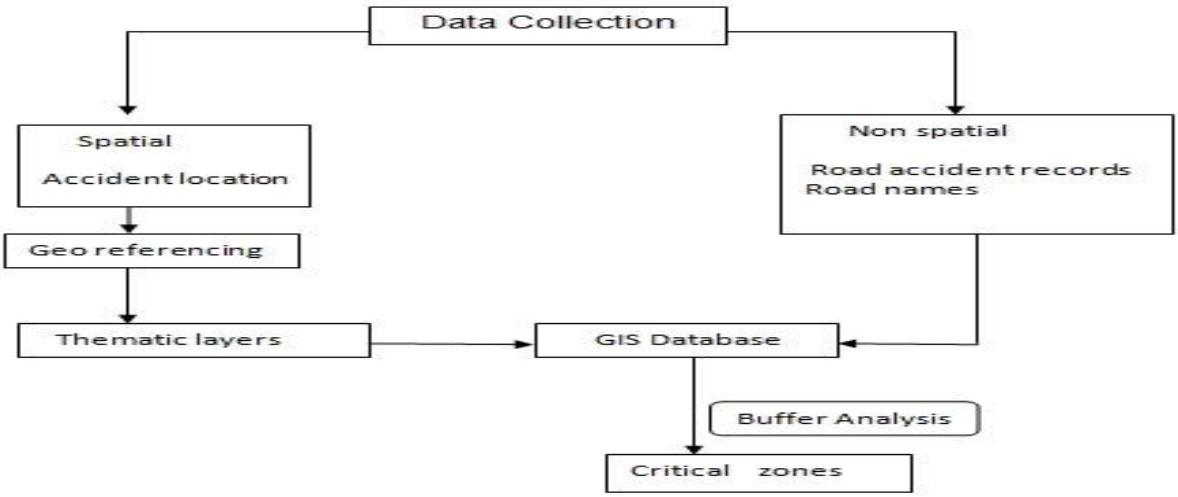
3.1 DATA COLLECTION:

In order to determine the accident prone locations, following data's are to be collected and used.

1. Police stations limit map obtained from the office of superintendent of police, Rourkela.
2. Accident reports for seven consecutive years.
3. Average traffic volume for seven consecutive years.

3.2 DATA PROCESSING :

The data processing involves the following steps. The flow chart of the data processing is shown below figure



3.3 MAP SCANNING:

The Survey of Rourkela topographical map was scanned as the raster input.

3.4 GEO REFERENCING:

Scanned maps usually do not contain information as to where the area represented on the map fits on the surface of the earth. To establish the relationship between an image co ordinate system and a map coordinate system the need to georeference the raster data emerges.

3.5 DIGITIZING:

Digitizing is the process of encoding the geographic features in digital form as x, y co ordinates.It was carried out to create spatial data from existing hard copy maps and documents. In the present work the georeferenced raster image of Rourkela city is digitized using Arc GIS9. This type of digitization is called onscreen digitization. Road network of the study area was digitized as line features. Accident locations are digitized as polygon features. The above spatial data were organized in a personal geodatabse and feature class. The exact location of accidents was identified by using “measure” tool in ArcGIS9.

3.6 ASSINGING ATTRIBUTES:

All vector data (i.e. line, polygon, point features) will contain separate attribute tables. Here each road is labelled with its corresponding name with the help of the city map obtained from the police station. Similarly the accident location attribute table contains the following data.

1. Year

2. Fatal accidents

3. Minor accident

4. Vehicles involved.

3.7 ACCIDENT PREDICTION MODEL:

For generating a accident prediction model, the traffic volume is computed as the average for each year in PCU/day and regression is carried out along with accident data using the curve fitting tool, available in MAT LAB. The best fit curve gives an accurate result in the accident prediction.

CHAPTER-4

STUDY AREA AND DATA COLLECTION:

4.1 STUDY AREA:

The survey was carried out at Rourkela (Odisha), India indicates that Rourkela is placed at 84.54E longitude and 22.12N latitude in Sundergarh region of Odisha at a height of something like 219 meters above mean ocean level. The region of Rourkela is around 200 square kilometers. Rourkela has an uneven and undulating geography .The city was once encompassed by woods and today there are two saved forests around the territory of the city. The Durgapur forest lies in the north of the town and the Sonparbat forest lies in the south. The Brahmani River streams in the west of the city. This seasonal river is formed by the confluence of two little tributaries the Koel and the Sankh that streams at the fringe of Rourkela.

Parts of the Rourkela city developed after the setting up of the Rourkela steel plant here. The old Rourkela zone or Purana Rourkela including Entabatti and Phulbari is the more established some older part of the city .The new parts of the city are Pamposh, Rourkela Township, and Ambagh. The occupied urban zones are Udit Nagar, Pamposh, Aam Bagh, Railway Colony, and the Industrial Estate . South Rourkela is dominatingly rustic in territories, for example, Jalda , Lathikanta, Pikodih, Tangarpali, Tarapur. The population in the encompassing ranges is basically tribal. Rourkela is connected through the National highway no 23 which passes through the

city. The NH 23 connects Jharkhand, passing through Rourkela, to Talcher in Odisha, at the junction of NH 42.

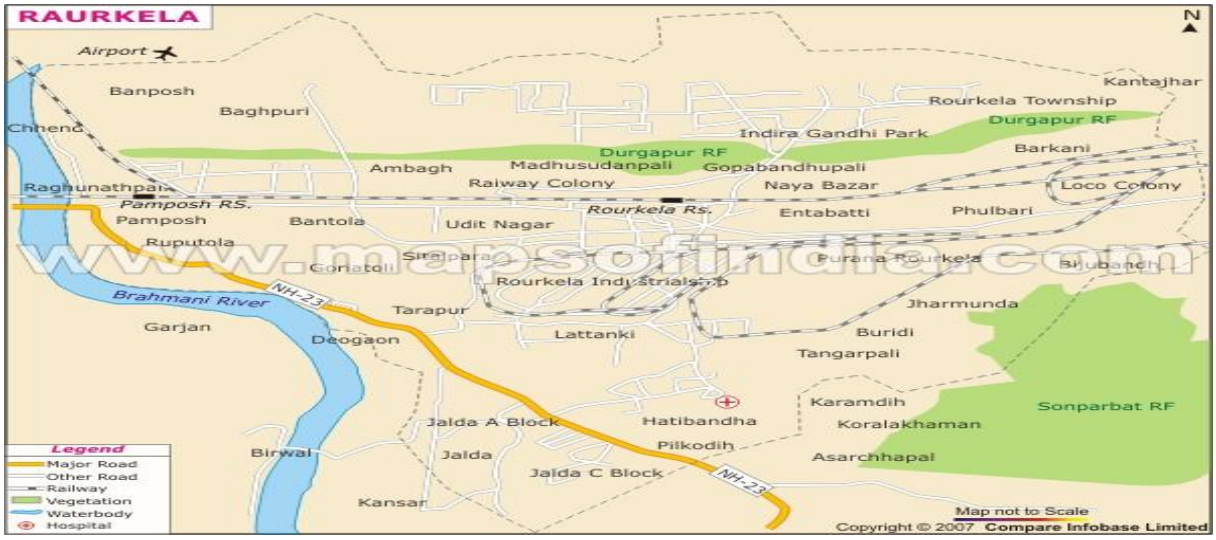


FIGURE 1: ROURKELA ROAD MAP

4.2: DATA COLLECTION:

The only information available for accident studies is the FIR (First Information Report) lodged in the police stations. The data from these records of last seven years(2006-2012) were extracted from the FIR record filed under IPCno.279/337/338/304(A),from:

- GRP Police Station,Railway Colony
- Raghunathpalli Police Station
- Udit Nagar,Police Station and Department
- Jhirpani police station

Rourkela was divided in seven zones and the accident data for each zone was tabulated:

- Zone 1-Takera to panposh
- Zone 2-bisra chowk to civil town ship
- Zone 3-chennd to sector 4
- Zone 4-air chowk to ambhagan chowk
- Zone 5-VIP road square to jhirpani
- Zone 6- sector 4 to IG park
- Zone 7-IG park to railway station

TABLE 1: Accident Data

ZONE 1:

SI.NO	YEAR	FATAL ACCIDENTS	MINOR ACCIDENTS
1	2006	2	15
2	2007	4	13
3	2008	1	19
4	2009	2	10
5	2010	2	22
6	2011	1	8
7	2012	1	11

ZONE 2:

SI.NO	YEAR	FATAL ACCIDENTS	MINOR ACCIDENTS
1	2006	2	13
2	2007	1	15
3	2008	1	18
4	2009	0	10
5	2010	2	6
6	2011	1	10
7	2012	2	14

ZONE 3:

SI.NO	YEAR	FATAL ACCIDENTS	MINOR ACCIDENTS
1	2006	3	7
2	2007	1	9
3	2008	2	5
4	2009	2	4
5	2010	1	3
6	2011	3	8
7	2012	0	6

ZONE 4:

SI.NO	YEAR	FATAL ACCIDENTS	MINOR ACCIDENTS
1	2006	5	12
2	2007	6	16
3	2008	7	14
4	2009	4	16
5	2010	6	20
6	2011	6	11
7	2012	7	16

ZONE 5:

SI.NO	YEAR	FATAL ACCIDENTS	MINOR ACCIDENTS
1	2006	2	11
2	2007	3	9
3	2008	2	10
4	2009	1	8
5	2010	4	12
6	2011	0	9
7	2012	1	6

ZONE 6:

SI.NO	YEAR	FATAL ACCIDENTS	MINOR ACCIDENTS
1	2006	3	17
2	2007	2	18
3	2008	4	14
4	2009	6	20
5	2010	2	18
6	2011	2	12
7	2012	3	15

ZONE 7:

SI.NO	YEAR	FATAL ACCIDENTS	MINOR ACCIDENTS
1	2006	4	16
2	2007	1	11
3	2008	2	11
4	2009	6	16
5	2010	9	18
6	2011	8	18
7	2012	5	16

P.W.D. (Public works Department) records are the main source for traffic volume data & road map. In addition to the above, road conditions information were also obtained from PWD records. Traffic survey was conducted at bisra chowk. Traffic volume for the year of count 2006 was extracted and represent in form PCU/day. It is assumed that the traffic volume is uniform throughout the study stretch. As the yearly traffic census data was not available for all the years, the available data were used to predict traffic volume on a road in each year for the period 2006-2012.

Geometric increase formula was used for forecasting the average PCU/day

$$A=P(1+\frac{r}{100})^n$$

Where, A = Predicted year traffic volume, P = Present year traffic volume

n= number of years r = A growth rate of 7.5% per year was assumed

TABLE 2:Annual accidents and Average traffic volume

SI.NO	Year	Number of accidents	Avg PCU/day
1	2006	105	21655.23
2	2007	98	18102.40
3	2008	104	21689.22
*4	2009	93	23315.91
*5	2010	114	25064.60
*6	2011	87	26944.45
*7	2012	95	28965.28

CHAPTER 5

ANALYSIS AND RESULTS:

5.1 ANNUAL VARIATION OF ACCIDENTS:

It is observed that accidents are increasing relatively in most of the year. In year 2007 accident rate increased suddenly, this type of situation occur may be due to the increase no of commercial vehicles and poor maintenance of road.

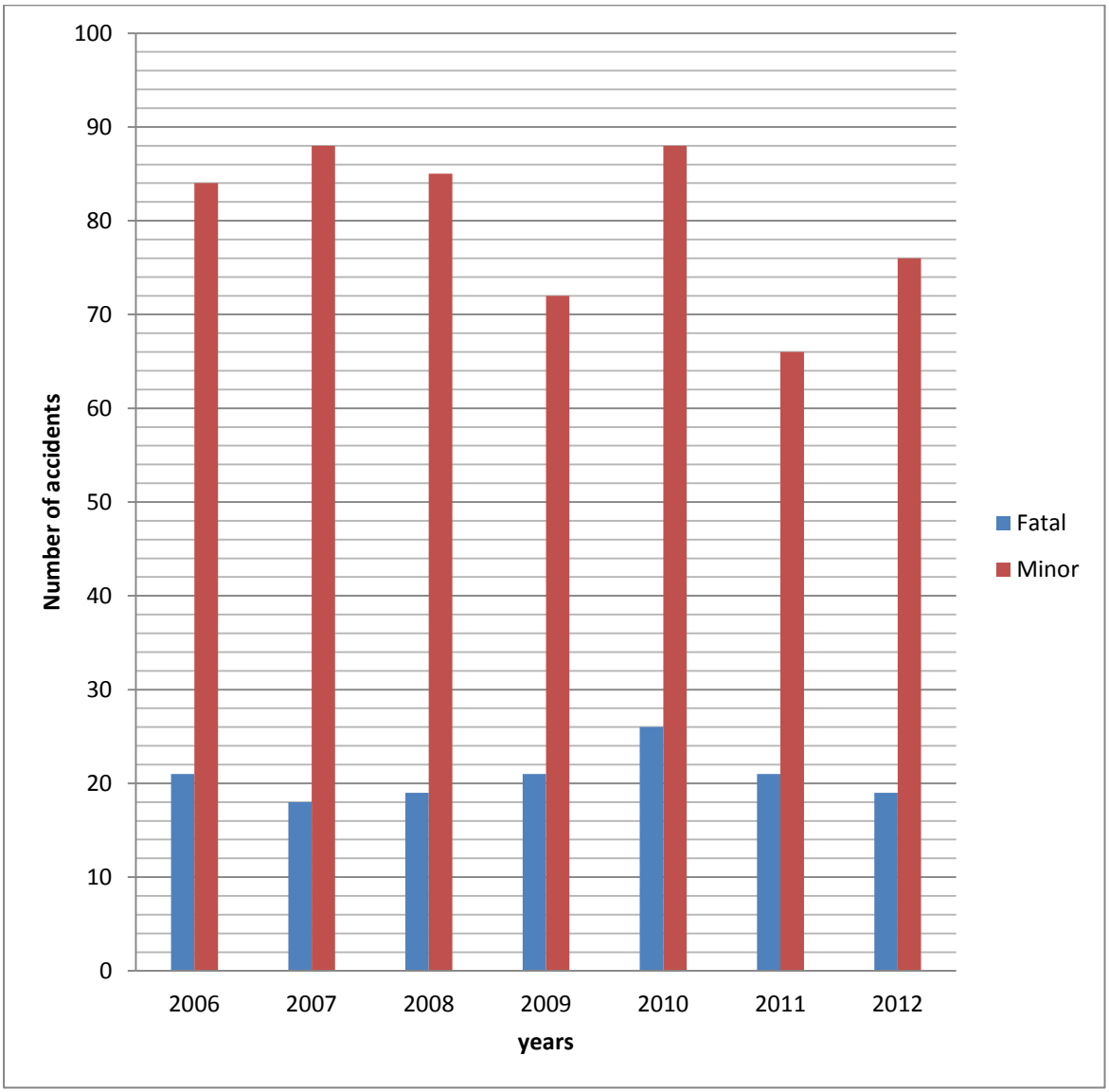


FIGURE -2: ANNUAL VARIATION OF ACCIDENTS

5.2 PREPARATION OF MAP:

Steps:

I. Took a google image of Rourkela city using snipping tool.

II. Layering the image in ARC GIS and then traced on it using polyline in another layer after that image layer is closed and a layered map of Rourkela is obtained.

III. Geo referencing is then done in ARC GIS by taking 4 ground control points.

IV. The map is fully digitalize

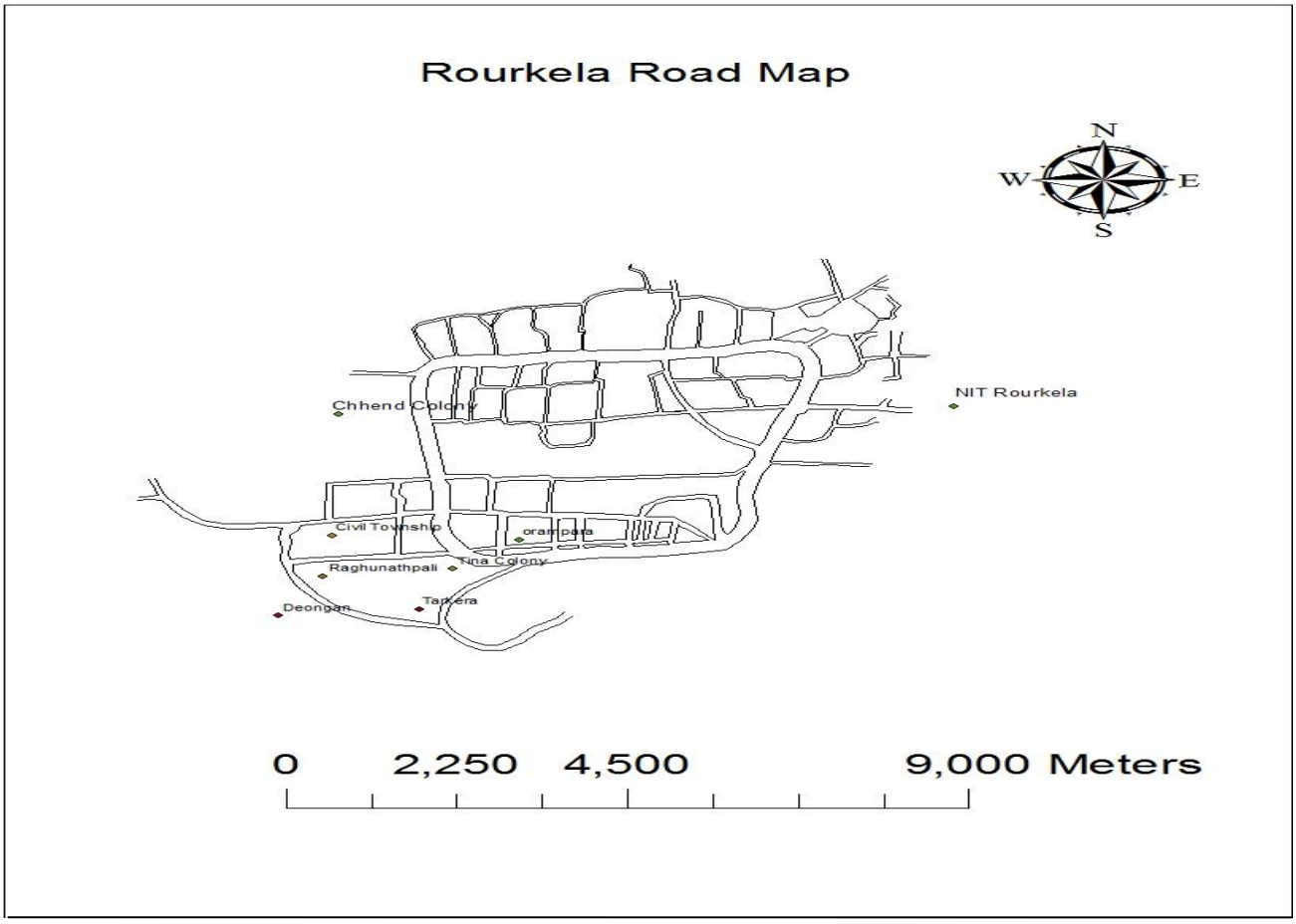


FIGURE 3: ROAD NETWORK OF ROURKELA IN ARC GIS

5.3 ASSIGNING ATTRIBUTES:

Using ESRI ARC GIS ,Rourkela road network is divided into seven zones using polygon entity .Then attribute table is formed for each zone

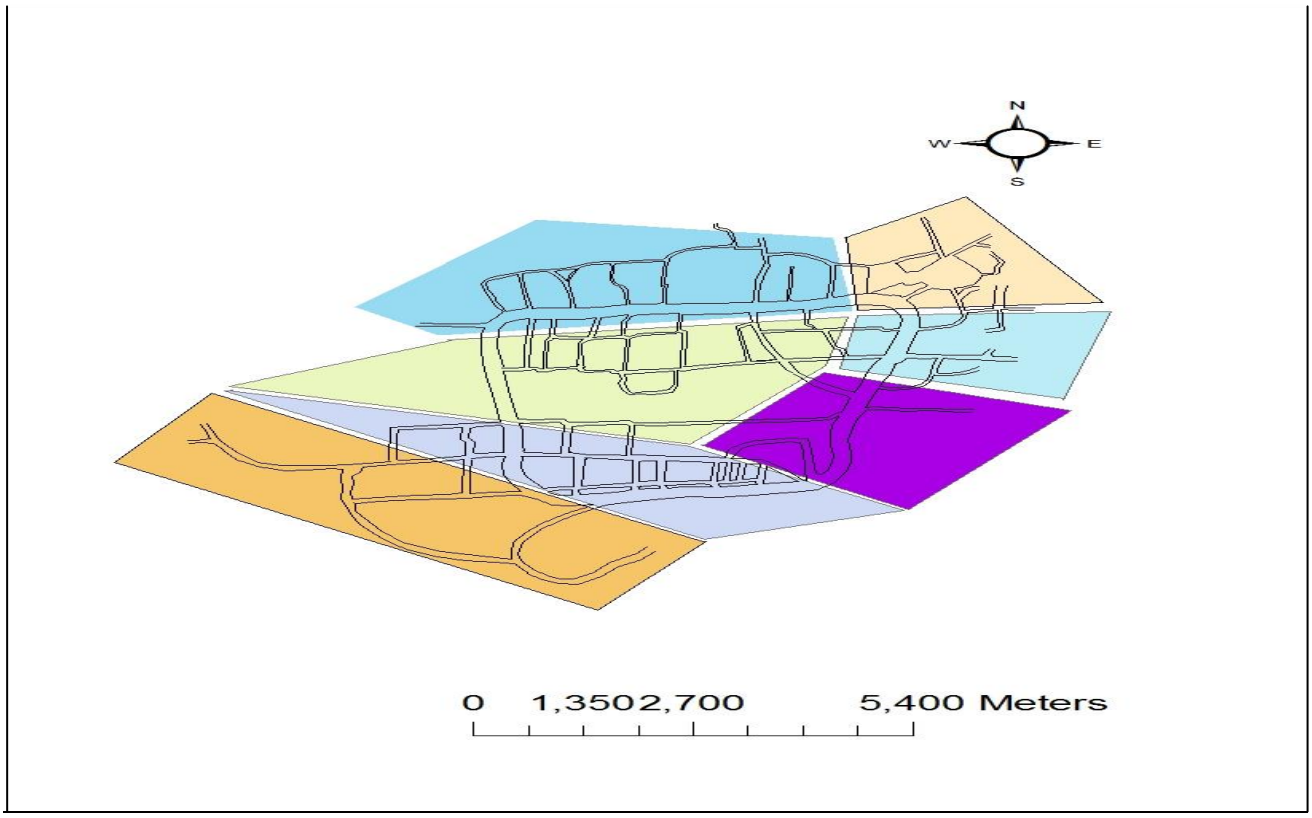


FIGURE 4: ZONING OF ROURKELA MAP

Attributes of zone 1

FID	Shape *	Id	Year	Fatal	Minor
0	Polygon	0	2006	2	15
2	Polygon	0	2007	4	13
4	Polygon	0	2008	1	19
5	Polygon	0	2009	2	10
6	Polygon	0	2010	2	22
7	Polygon	0	2011	1	8
8	Polygon	0	2012	1	11

Record: Show: All Selected Records (0 out of 7 Selected) Options

FIGURE 5: ATTRIBUTE TABLE

5.4 BUFFER ANALYSIS:

To determine the accident prone area proximity analysis is to be done using ARCGIS, which gives a visualization of the critical zones where accidents are likely to occur and proposals are to be suggested for avoiding crashes. The overlapping of buffer zones indicates the critical zones. Buffering and overlay are two of the most common operations in cartographic modelling. A buffer zone is an area that is within a given distance from a map feature. Buffering on a set of features, the output is a set of polygons. (Buffering points or lines creates a new polygon layer). These polygons define an **inside region**, an area less than the specified buffer distance from the features of interest and an **outside region**, an area more than the specified buffer distance from the features of interest. These inside and outside regions are typically distinguished by different codes in an attribute table.

The generated different thematic maps were overlaid and were linked with the entire attribute data on the GIS platform as the result obtained by the statistical and spatial analysis were represented visually. Demarking the accident prone Areas according to the priority and recommendation of suitable remedial measures were made according to the specific location.

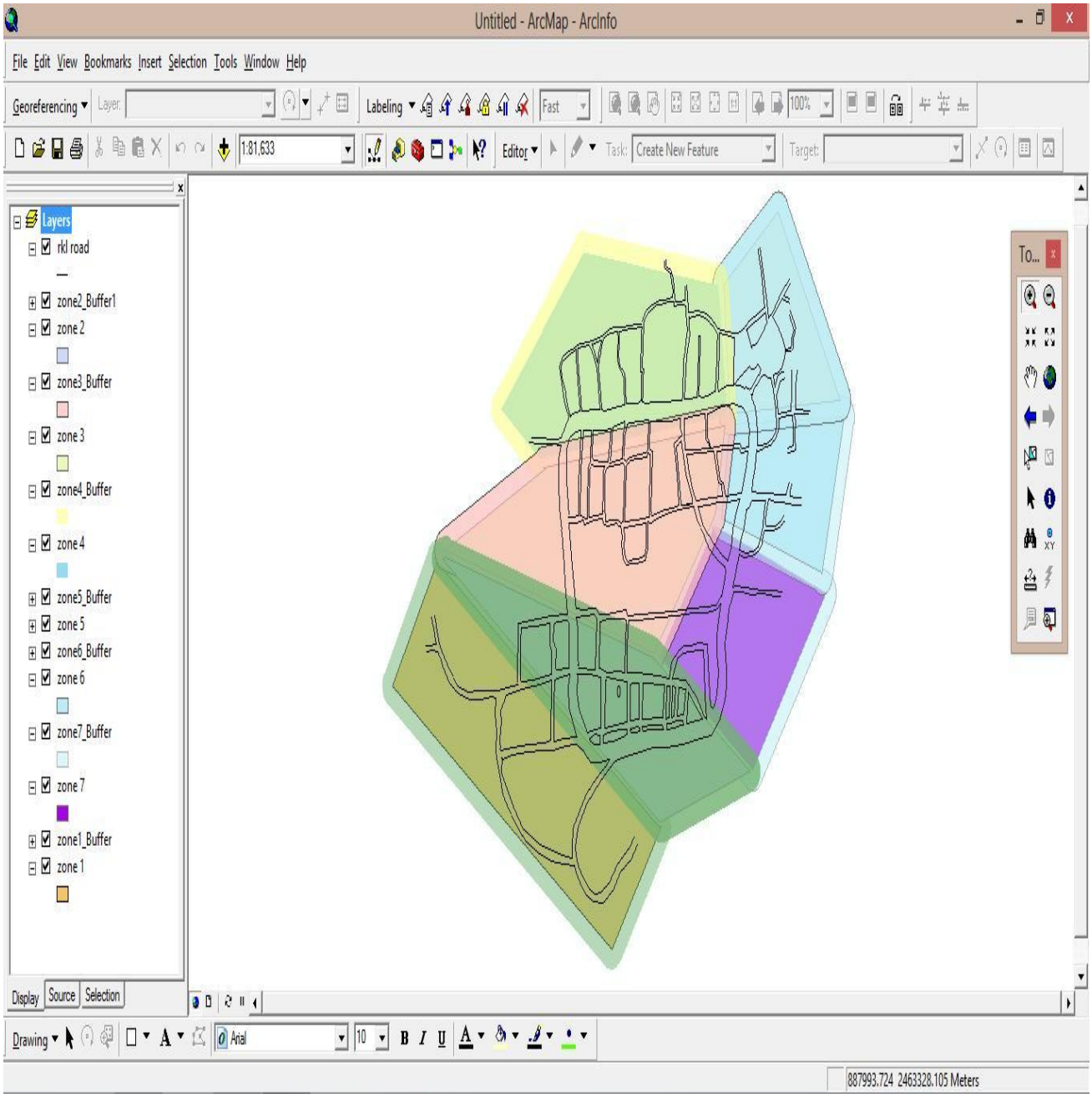


FIGURE 6: BUFFER ZONES

5.5 ACCIDENT PREDICTION USING MAT LAB:

Curve Fitting Toolbox provides functions for fitting curves and surfaces to data. The toolbox helps in performing exploratory data analysis like regression, using this tool a relation between accidents per year and average pcu/day is established.

Two cases are considered:

1. Straight line regression
2. 6 degree polynomial regression.

Both the cases show the extreme regression that can occur for the accident data and average traffic volume per day .The best fit curve obtained depicts the accuracy of the prediction. The equations are customized and then the curve is plotted .The accuracy of the regression is checked by the value of correlation (R) which should be close to one for better fitting of the curve ,the regression coefficient is the standardized slope of the regression line which tell the relationship between the two variable .It is a good indicator for the strength of the relationship

Coefficient of determination (R^2) shows the proportion of variance of accidents per year, which can be predicted from the average traffic volume per year.

A least square regression chooses the line with the lowest sum total of the square prediction error (SSE),the less is the SSE the more accurate is the result.

1. **Straight line regression** :

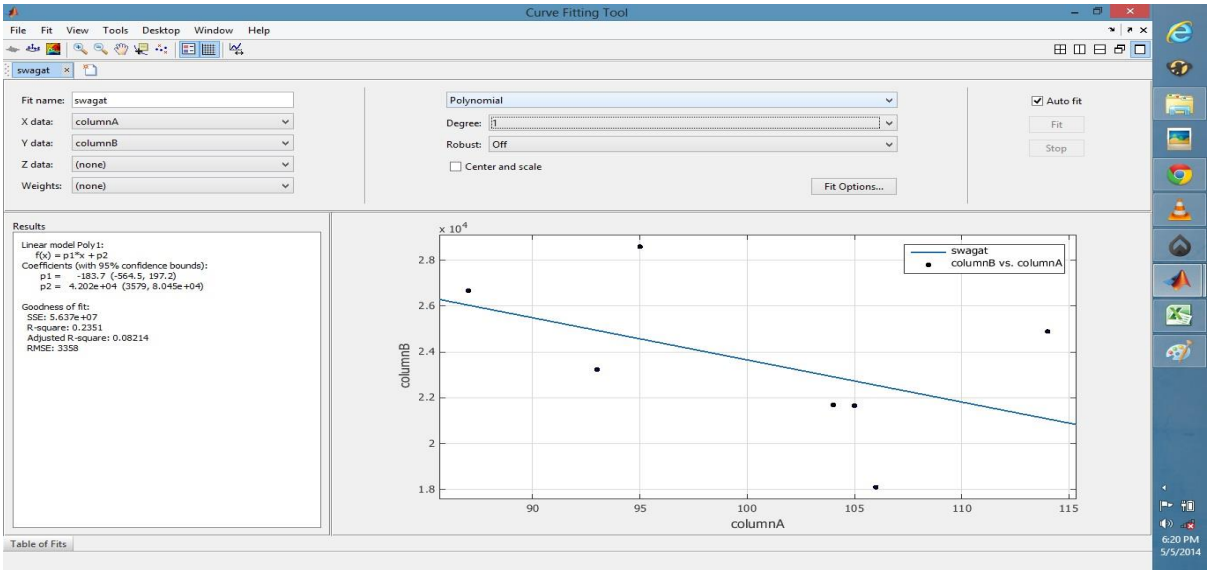


FIGURE 7: STRAIGHT LINE REGRESSION

The equation obtained: Accidents/year = -183.7×average PCU/day + 4.202×10^4

SSE=5.637×10^7

R=0.2351

Confidence limit=95%

Inference:

This curve shows the least accurate result as the coefficient of correlation is very less and the sum of square of errors is more so another polynomial equation is customized And the value of R and is R^2compared with the previous equation.

Likewise a number of equation are customized by increasing their degree by one and the parameter are noted and compared.

2. **6 degree polynomial regression** :

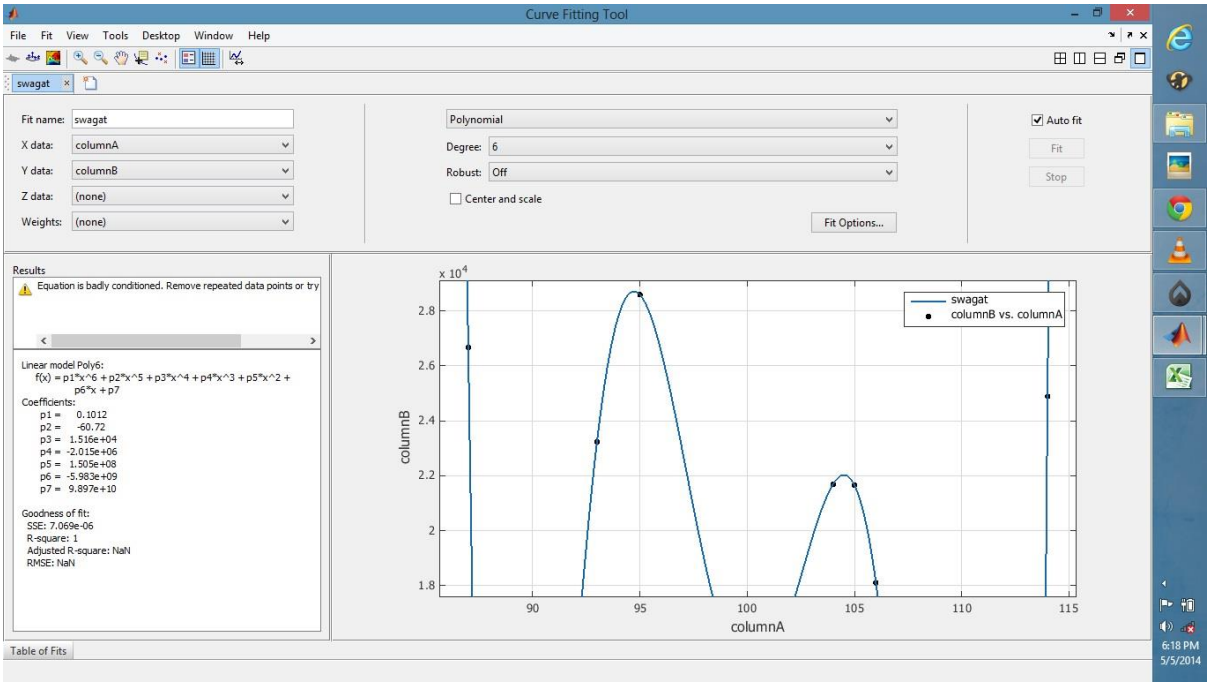


FIGURE 8: 6 DEGREE POLYNOMIAL REGRESSIONS

The equation obtained: Accidents/year = $0.1012P^6-60.72P^5+(1.516\times10^4)P^4-(2.015\times10^6)P^3+(1.505\times10^8)P^2-(5.983\times10^9)P+(9.87\times10^{10})$

P=Average PCU/day

SSE=7.069×10^6

R=0.92

Inference:

As the data of only seven consecutive years are provided, the best fit curve could only be a 6 degree polynomial equation; this is validated by the regression coefficient which is 0.92 which is close to 1.

CHAPTER 6

SUMMARY AND CONCLUSION:

6.1 SUMMARY:

Accident analysis of Rourkela city is of great significance, since there has been a rapid Increase in accident rate for the seven consecutive years which is taken into observation .

Buffer analysis is made using the proximity analysis tool available in ARC GIS .

Overlapping of these buffer zones shows the accident prone area of Rourkela .essential accident data required for buffer analysis are collected from various police stations of Rourkela.

An accident prediction model is also designed by performing regression between the annual accidents per year and average traffic volume using MAT LAB. (Public works Department) records are the main source for traffic volume data. In addition to the above, road conditions information were also obtained from PWD records. Traffic survey was conducted at bisra chowk. Traffic volume for the year of count 2006 to 2012 was extracted and represent in form PCU/day.

6 degree polynomial regression results in best fitting curve which depicts the best model for the accident prediction of Rourkela.

6.2 CONCLUSION:

- Zone 2 has more critical zones ,the apprehended reasons are:
    - Sight distance near curve is obstructed by girth trees and ditches are on the curve shoulder
    - A lot of dhaba, garrage for heavy machinaries are on either side of roads and on street parking results capacity reduction.
    - Carriageway and shoulder is used as bus stop near the cross junction.
    - Sight distance obstruction at curves by bushy trees.
- Zone 1 is also vulnerable to accidents because:
    - Heavy traffic due to commercial and non commercial vehicle.
    - Unsignalised intersections
    - Truck accidents are more vital, because this route is taken to RSP.
    - Presence of trees on the shoulder.

The preventive measures that ought to be taken:-

- It is necessary to raise awareness among road users especially for truck drivers.
- Speed limit should be brought down in accident prone stretches
- Shoulder maintenance should be done frequently
- Capacity of road shall be increased by making the road into four lane
- Sight distances should be obstruction free.

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