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Road Safety Analysis of Urban Roads: A Case Study of Pimpri-Chinchwad Municipal Corporation

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ABSTRACT: In this study, an analytical and theoretical methodology for the calculation of urban branch road safety is proposed. The project relies on data collected during road safety inspections; therefore, it can be implemented with the help of historical data about traffic volume or accidents available. It permits us to identify geometric, physical, functional, and transport-related defects, and elements which are causal factors of road accidents, in order to assess the risk of death or serious injuries for users. Traffic volume, average speed and expected consequences on vulnerable road users in case of an accident allow us to calculate both the level of danger of each homogeneous section which composes the road, and the hazard index of the overall branch. A case study is presented to implement the proposed methodology. The strategy proposed by the authors could have a significant impact on the risk management of urban roads, and could be used in the design safer roads and improve the safety of existing roads.

KEYWORDS: Road Infrastructure, Network of Road Safety, Urban Road Safety Inspections.

I. INTRODUCTION

User safety is one of the most important issues in road design. In order to prevent accidents and reduce their consequences on people, the system composed of drivers, vehicles, the environment, and roads should be investigated. According to several studies available in the literature, most accidents are caused by bad behavior of drivers, i.e., the only ones capable of adapting their behavior towards nonliving components. However, it has been observed that the incorrect design or management of road infrastructure can induce bad behavior or failure to appreciate risk. Therefore, in order to maximize on-going safety efforts, it is necessary to analyze each component of the road system and evaluate its effect on road safety. On the safety management of road infrastructure establishes management procedures ensuring the safety of road networks. It helps and defines four basic tools for road safety management: Road Safety Impact Assessment, Road Safety Audit, Safety Ranking and Management of the Road Network in Operation, and Road Safety Inspections. These activities work on planning, design, and management of both constructed and to-be-constructed roads included in the Transport Network. The proposed method will allow for an objective assessment of the risk level, the numerical and statistical results of the analysis are comparable to a target level of risk to be defined during the analysis.

II. OBJECTIVES

- To study the system of traffic safety management in PCMC area.
- To recognize the reasons of fatal accidents in PCMC area.
- To suggest remedial measures for improving safety on the roads.

III. METHODOLOGY

In this study, the project work proposed an innovative quantitative approach to assess the Branch Index Risk (BIR) and the Section Index Risk (SIR) of existing urban roads considering their geometry, layout, users, and traffic. BIR assesses the overall risk of road accidents in urban branch roads: the higher BIR value, the lower the safety along the examined infrastructure stretch. Therefore, the value of BIR depends on the Section Factor Risk (SFR_{j,r}) of each homogeneous section j which composes the branch r .

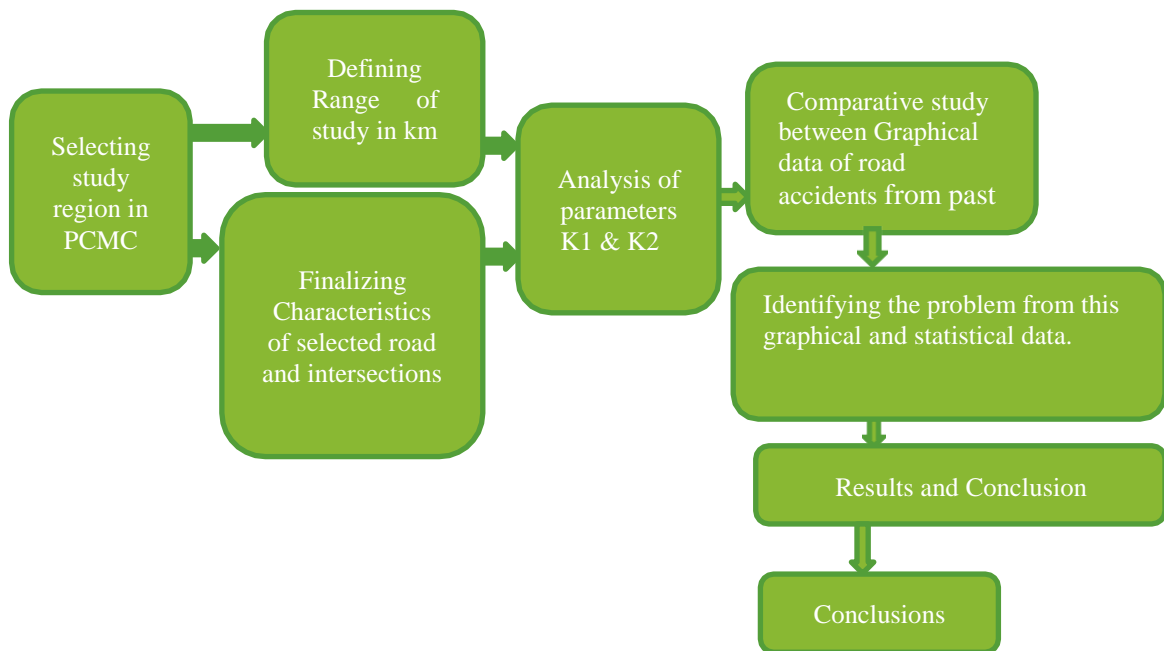


Figure : 3.1 : Project Methodology

Each homogeneous section is 100 m ± 20%-long: road branches are considered. If they have uniform/homogeneous attributes related to physical and operating conditions (i.e., accident rate, geometric layout, composition of cross section, traffic spectrum, average operating speed). This approach allows for the comparison of “density” of hazardous elements/defects between different (short) sections whose length is suited to the considered urban context. moreover, it gives good results in terms of fitting the safety performance of road sections, as confirmed by P.C.M.C. SFR_{j,r} takes into account both the general characteristics of r (i.e., type and frequency of hazardous elements/defects, expected damage on vulnerable road users, and traffic level), and all n elements which affect the dangerousness of j. Equation (1), which complies with an approach recently proposed to analyze and plan maintenance of road safety barriers, allows us to calculate SFR_{j,r}:

$$SFR_{j,r} = \sum_{i=1}^n K_{1i} \times K_{2i} \times K_{3i} \times K_{4i} \times K_{5i} \times B_i \quad (3.1)$$

Where,

B_i is the base value associated to defects i which are along j.

K_{1i} is the priority factor of the category to which the element i belongs.

K_{2i} is the vulnerability factor of users (i.e., pedestrians, cyclists and motorcyclists) along r; and it depends on their volume.

K₃ is the motorized traffic factor of r.

K_{4i} is the hazardousness factor; it depends on the consequences of defect i on the most vulnerable road users.

K_{5i} is the extension factor; it depends on continuous or discrete elements/defects i along j. Given SFR_{j,r}, the corresponding value of SIR can be calculated according to Equation (3.2)

$$SIR_{j,r} = SFR_{j,r} / SFR_{max,r} \times 100 \dots \dots \dots (3.2)$$



Where,

$SIR_{j,r}$ is the Section Index Risk of the section j belonging to r , and $SFR_{max,r}$ is the highest value of SFR_r by attributing the maximum values to defects found on r . Therefore, $SFR_{j,r}$ depends on the detected road elements/defects and the road users of the section j , and $SIR_{j,r}$ depends on the comparison between the attributed and the maximum values of of $K_{1i}, K_{2i}, K_{3i}, K_{4i}, K_{5i}$.

Similarly,

The Branch Index Risk BIR_r can be calculated according to Equation (3.3):

$$BIR_r = R_r / R_{max,r} \times 100 \tag{3.3}$$

Where,

R_r is the sum of the $SIR_{j,r}$ of m sections which compose the road branch r given by Equation (3.4)

$$R_r = \sum_{j=1}^m SIR_{j,r} \tag{3.4}$$

$R_{max,r}$ is the reference value of the Risk Factor given by Equation (3.5)

$$R_{max,r} = m \times SFR_{max,r} \tag{3.5}$$

Similar to $SIR_{j,r}$, BIR_r depends on the attributed values of $K_{1i}, K_{2i}, K_{3i}, K_{4i}, K_{5i}$ and on the defects found along r . Both $SIR_{j,r}$ and BIR_r range between 0 and 1.

Parameters for Analysis:

The implementation of the proposed method requires road inspections to identify and categorize elements and/or defects of infrastructure which could cause accidents.

The projects identified 8 categories of elements/defects:

- i. Geometry(G),
- ii. Cross-section(C);
- iii. Pavement(P);
- iv. Lighting(L);
- v. Road signs(S);
- vi. Intersection(J);
- vii. Urban furniture (F);and
- viii. Stopping(ST).

The attribution of possible values of $K_{1i}, K_{2i}, K_{3i}, K_{4i}, K_{5i}$ and B_i required interviewing technicians from different backgrounds as well as academic experts in the fields of roads The project work defines for each variable, the maximum and minimum value, then each technician attributed the values within the established ranges. Finally, the geometric mean will be used to aggregate individual judgments.



Table 1. Priority factors values of considered elements.

CATEGORY	CODE	K1
Geometry	G	0.9
Cross section	C	1.0
Pavement	P	0.8
Lightning	L	0.5
Road signs	S	0.7
Intersections	I	1.0
Urban furniture	F	0.6
Stopping	ST	0.4

In all total, 35 identified road elements/defects which can cause accidents. Their base values B_i satisfy Equation (3.6) and are listed in Table 2. Road alignment and geometry were evaluated against the Indian standards and recommendations about the geometric and functional characteristics of roads and intersections, road infrastructure safety management, and road lighting. These standards were considered as references to identify “not compliant” conditions, and to assign the B_i values.

$$1 \leq B_i \leq 4 \tag{3.6}$$

K_{2i} depends on the observed traffic condition of vulnerable users (i.e., pedestrians, cyclists, and motorcyclists) which are exposed to the risk induced by defect i . The Highway Capacity Manual suggests performing surveys during a 15 min count period in order to obtain the traffic volume data. The authors observed the traffic flow when weather conditions were not an obstacle to traffic, and when all work- and school-related activities were ongoing. Finally, they calculated K_{2i} according to Equation (3.7).

$$K_{2i} = K_{Pi} \times K_{Ci} \times K_{Mi} \tag{3.7}$$

Where,

K_{Pi} , K_{Ci} , K_{Mi} depend on the pedestrian, cyclist, and motorcyclist flow respectively. Their values satisfy Equations (3.8), (3.9), (10) and depend on traffic volume observed along the overall examined branches, if the analysis involves a road network.

$$1 \leq K_{Pi} \leq 2.5 \tag{3.8}$$

$$1 \leq K_{Ci} \leq 2.5 \tag{3.9}$$

$$1 \leq K_{Mi} \leq 2.5 \tag{3.10}$$

Table 2. Road accidents in Maharashtra during year (2016-2020)

Year	No. of road accidents	No of people killed	No of people injured
2016	39848	12883	35894
2017	35853	12264	32128
2018	35717	13000	31152
2019	30084	11870	30856
2020	8200(upto june)	3214	6154

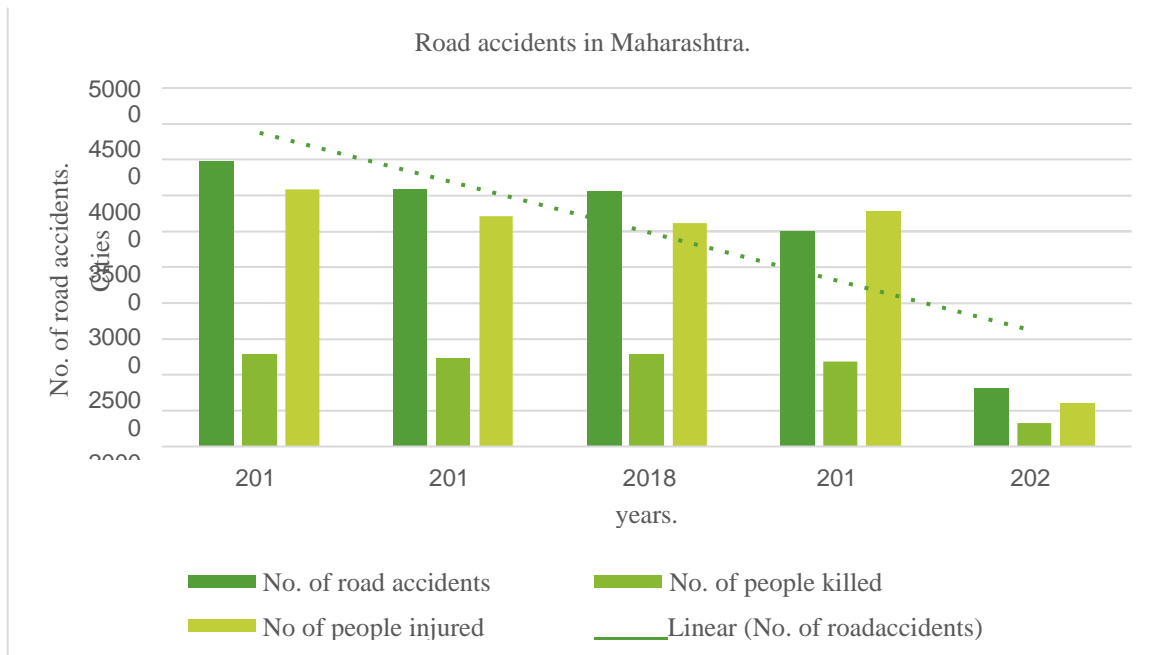


Figure 3.2: Comparison of road accidents in past few years.

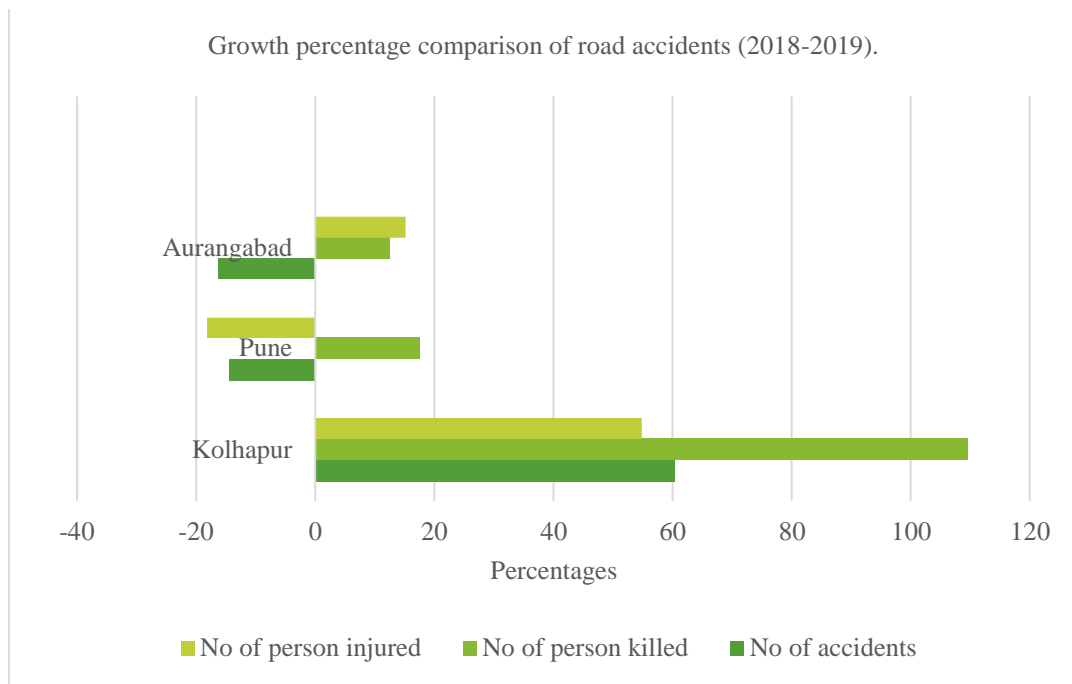


Figure 3.3: Comparison of road accidents in 3 cities.

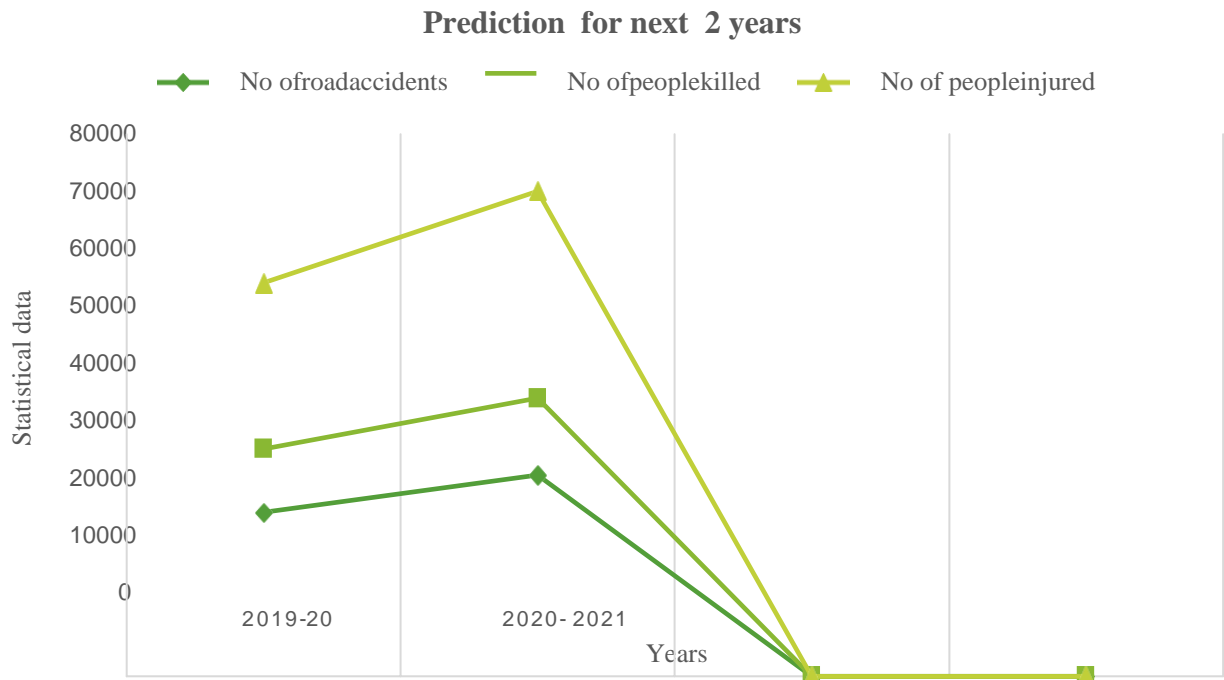


Figure: 3.4: Prediction on basis of past few year statistical data.

Reconnaissance survey to study area and collection of data for analysis:



Figure 3.5: Construction activity near road.

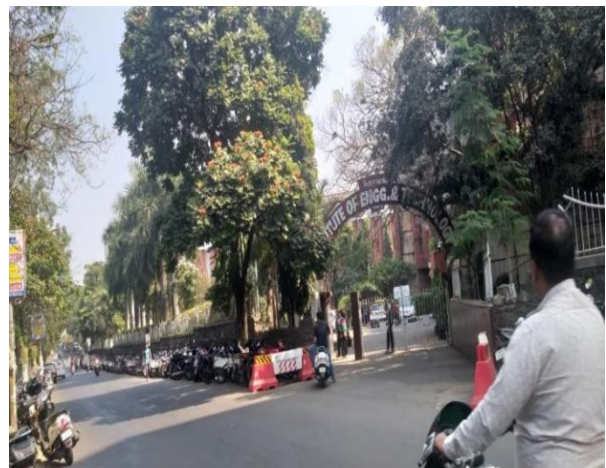


Figure: 3.6: Roadside parking near area.



Figure:3.7: Underpass ways in study near Nashik Phata P.C.M.C.



Figure: 3.8: Traffic intensity at pick hours.



Figure: 3.9: Invisible traffic control.

IV. CONCLUSION

The study proposed a methodology based on the quantitative and theoretical inspection to interpret the results from various statics and graphical data of past few years on urban roads. The results from statics and graphical data of roads in pune region theoretically may have good performance of the proposed data. All the work required for improving urban road safety is sensitive to improvements of infrastructure as well as the users skill of driving. The method depends on the assumed ranges of variables and risk classes, as well as on the values attributed to the variables used for calculating the hazard index of examined homogeneous road sections and branches. Therefore, both the Section Index Risk (SIR) and the Branch Index Risk (BIR) depend on geometric, functional, physical, and environmental defects or elements which are potential source of road accidents. These factors are then related to the involved vulnerable road users and to existing traffic flows to assess the current levels of risk.

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