ABSTRACT

The research aims at to study the impact of traffic characteristic on road user, which is tracking as contributor, generated at individual and spread to traffic. Risk is intuitive reaction by the road user to what he perceives to be unanticipated situations or dangers such as stress, emotional outburst, influence of liquor, sudden disturbance on the road etc., when travelling. Risk is expression of the road user and it is a dye of influence generated by speed, headway and delay with variable intensities/contributors, which leads to congestion and accident occurrence.

Urban congestion and risk on travel are the two major issues which are influencing road user. This influence is effecting on economic travel, non-sustenance of environment, psychological strains and a travel imbalances on traffic mobility. There is a need to identify the risk cause for the phenomenal influence rendered in traffic. From various research findings it is found that risk is the expression of road user spatially on interaction over a time and space. This risk is quantifiable and can be tracked with the attributes positioned on road with head way, speed and delay. The risk which is generated with the above heads are distributed with variable intensities and lead to the congestion and accident occurrence. These intensities are found that they are due to influence of certain characteristic influence from factors of land use, road geometrics, and traffic and road network characteristics. This study is framed on risk
analysis with the multilevel influencing factors. GPS Technology, GIS based supportive approach and data collected from field survey are suggested in this research as data input and a mathematical model is applied to find risk dependency and risk generation and distribution.

The objective of the study is to develop a scientific approach for the risk generation, distribution and occurrence and the factors which are responsible for the risk of travel. Urban mobility is affected due to number of reasons such as the demand concentration on the favorable spatial structure, imbalances in the modal split, inadequate use of infrastructure, rapid growth of urbanization, etc. Urban transport environment is effected and leads to poor quality of life, uneconomical travel, causes psychological strain, risk occurrence, etc. Indian policies and the literature concerned with the risk have identified the need for the risk analysis to tackle the issues related to congestion. The majority of the existing studies on the risk behavior addresses on the network design and the choice of route based on the conventional travel demand modeling but there is no scientific approach for how the risk is generated at one place and distributed to other places and finally the risk generated at the centre of CBD area or the city is due to the risk or delay carried from the remote places. This study provides a conceptual framework to analyze parameters which are responsible for risk and for the occurrence of risk at one place and risk distribution and risk concentration at the other places.

Road network characterization surveys and traffic characterization surveys are conducted in the study area. Identifying congestion in the
links of the network is an important task in integrated planning. The performance and functionality of a link can be attributed to many characteristics including the neighborhood characteristics of the link and there is a research gap in finding the exact criterions which are the real factors of risk generation. So the link has to be evaluated based on these conflicting multiple attributes at one point of time. Risk analysis has been done through Principal component analysis followed by causal techniques to identify the factors contributing to risk generation and the major links which are leading to congestion.

**Principal component analysis**

The central idea of principal component analysis (PCA) is to reduce the dimensionality of a data set consisting of a large number of interrelated variables, while retaining as much as possible of the variation present in the data set. This is achieved by transforming to a new set of variables, the principal components (PCs), which are uncorrelated, and which are ordered so that the first few retain most of the variation present in all of the original variables. (Jonathon Shlens).

Principal component analysis is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences (Joliffe I.T, Jonathon Shlens)

The PCA model can be represented by

\[ U_{m	imes1} = W_{m	imes d}X_{d	imes1} \]

where \( U \), an m-dimensional vector, is a projection of \( X \) - the original d-dimensional data vector \( (m << d) \). It can be shown that the m projection vectors that maximize the variance of \( U \), called the
principal axes, are given by the eigenvectors $e_1, e_2, \ldots, e_m$ of the data set's covariance matrix $S$, corresponding to the $m$ largest non-zero eigenvalues $\lambda_1, \lambda_2, \ldots \lambda_m$.

The data set's covariance matrix $S$ can be found from:

$$S = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \mu)(x_i - \mu)^T$$

Where $\mu$ is the mean vector of $x$. The eigenvectors $e_i$ can be found by solving the set of equations:

$$(S - \lambda_i I)e_i = 0 \text{ for } i = 1, 2, \ldots, d$$

Where $e_i$ are the eigenvalues of $S$. After calculating the eigenvectors, they are sorted by the magnitude of the corresponding eigenvalues. Then the $m$ vectors with the largest eigenvalues are chosen. The PCA projection matrix is then calculated as:

$$W = E^T$$

Where $E$ has the $m$ eigenvectors as its columns. Here $W$ is a $m \times d$ matrix.

**Algorithm for risk analysis**

Design phase includes the standardization of the raw data for the analysis. The problems are analyzed by maximizing or minimizing a linear function of a number of variables (Black W.R. 2003).

Value function method of standardization for normalizing the data is adopted. The following method is used in assessing the value function.

**Step-1:** Determine the range over which the link is to be assessed (i.e., set the lower and upper bounds of the value scale) and assign a value of 0 to 1 to these end points, respectively. Based on the objective
function defined as above, the end points are assigned to each scale. The objective function defined for the traffic characteristics is “maximization of criterion” the criterion where values are arranged in ascending or descending order. As the objective function intends at maximization, the maximum value in the range has the better values of risk generation. Hence this value will be assigned a value of 1 and the lowest value in the data will be assigned a value of 0.

In the case of minimization, for minimization criterion, the minimum value in the range will be assigned a value of 1 whereas maximum value is assigned a value of 0.

**Step-2:** Input values are standardized by subtracting either the minimum value or maximum value from the respective characteristic vector and dividing it with the difference between maximum and minimum value.

**Step-3:** Calculation of the covariance matrix

The covariance of the above matrix is found using the PC software

**Step-4:** Calculation of the eigenvectors and eigen values of the covariance Matrix

**Step-5:** Calculation of the Principal components

**Step 6:** Deriving new Dataset

The final values are obtained by multiplication of the one transposed matrix i.e Principal components matrix and Standardized matrix. The final values obtained are the standardized values.
**Step-7:** Taking speed, delay and headway as independent characteristics, the regression equation is found out using MATLAB, the commands for finding coefficients are

\[
X = \text{[ones (size(x1)) x1 x2 x3 x4 ...]}\\
A = X \backslash Y
\]

Where

- \( X \) = dependent variables
- \( x1, x2, x3 \ldots \) are geometric, traffic, land use and Utility characteristics found by the Principal component analysis
- \( Y \) = speed, delay, headway respectively in each analysis of major criterion
- \( A \) = regression coefficients

**Step-8:** Finding the dependency

The percentage influence of each criterion is found based on the regression coefficients. The criterions which depend upon each independent characteristic i.e., speed, delay and headway are found based on essential tests. The tests essential for establishing the values of Residual, SSE, R-Square, DFE, RMSE (Standard Error), significance of correlation coefficient, t test, F test and P tests have been conducted.

**Step-9:** The prioritization of the links based on the ideal speeds and delays obtained by the analysis is done in reference to the input or the exact values of the traffic characteristics. This dependency is useful in judging the importance of study area based on the criterions.
The ideal speeds, headways and delay values are compared with the initial values in the study area and it is easy to find where the risk occurs and how it is distributed from one place to many places and concentrated at a place which is the combination of the total risk.

**Step-10:** The data is analyzed with one or more models.

The analysis deals with the following factors:

- Numerical fit analysis
- Graphical fit analysis

The graphical measures deal with the residuals and prediction bounds and the numerical measures deal with the goodness of fit statistics such as

a. Sum of squares due to errors (SSE)

b. R-Square

c. Root mean square error (RMSE) i.e, Standard Error

d. Degree of freedom (DFE)

e. Significance of slope or coefficient tests i.e, F test and t test

Three municipalities of Cyberabad region of Ranga Reddy district namely Gaddiannaram, Rajendranagar and Qutubullapur have been delineated as the study area. The study area of 3 municipalities is 107.78 sq.km as per the data obtained from the satellite data. The land use activities are predominantly of mixed type constituting residential, semi-residential, commercial and industrial. There is no defined functionality of the road systems in the Municipalities. The hierarchy is of major and minor roads only. There are many
development initiatives proposed around the municipalities in the recent past.

To identify the exact criterions and the links which leads to congestion and to study which are the real factors of risk generation certain criterions are considered.

• The broad criterions are categorized in four groups – Geometric characteristics, Traffic characteristics, Land use or road side characteristics and Utility characteristics.

• The attributes considered under each criterion with objective function are as follows.

Geometric characteristics

1. Roadway width (RW) - Minimum
2. Carriageway width (CW) - Minimum
3. Stopping sight distance (SSD) - Minimum
4. Number of curves (NC) - Maximum
5. Pavement Condition index (PCI) - Minimum

Traffic characteristics

6. Headway (H) – Minimum
7. V/C Ratio (VCR) – Maximum
8. Intensity of Parking, business activities and road side activities (PBE) – Maximum

9. Speed (V) – Minimum
10. Delay (D) - Maximum

Land use or Road side Characteristics

11. Number of access points on the link (NA) - Maximum
12. Commercial area (CA) - Maximum
13. Residential area (RA) - Maximum
14. Semi Residential area (SRA) - Maximum
15. Industrial area (IA) - Maximum

*Utility characteristics*

16. Overlap size of the link from static analysis (OS) - Maximum
17. Trip intensity on the link (TI) - Maximum

From the research, the contributors which are responsible for risk generation on major corridors that leads to congestion and distributed to other corridors are identified. In this analysis it is taken into account all the geometric, traffic, land use, utility characteristics by considering speed, headway, and delay as major contributors for risk generation.

All the major contributors are tested for good fitness and they satisfied all required parameters. Prediction graphs shows that they are within 95% prediction bounds. From the comparison of parameters to get good fit graphical analysis, computational analysis, strength and significance tests, it is observed that they are good fit for 3\textsuperscript{rd} degree polynomial for Gaddiannaram municipality area, 5th degree polynomial for Rajendranagar municipality area and 6\textsuperscript{th} degree polynomial for Qutubullapur municipality area.

Study on urban mobility under the perspective of risk generation has given a unique platform on control strategies of urban congestion. This study has given a finding that urban risk is dependent not only on road user behavior, but also depends on infrastructure planning,
land use pattern and traffic characteristics. Even though the road user carries risk, he need not be the sole reason for the generation of urban risk. It is also found that risk is carried by user with dominant influence of infrastructure, traffic, land use and road geometric characteristics.

The thesis focuses on the improvement of operational performance of the supply system in terms of the risk occurrence and distribution with respect to congestion and the objective framed in the study. Risk occurrence is a dye of the influence injected by road user through his reactions on the road. This sudden injection of individual reaction characteristics leads risk occurrence. This event is accompanied by undesirable situations. The study involves in planning of the road network with respect to congestion and the factors responsible for the risk generation. The study is framed in two modules.

1. Development of the road network and the factors responsible for congestion and their levels i.e., finding the dependency of the risk generators.

2. Existing supply system improvement through the prioritization of the major corridors with respect to congestion to serve as a tool for road administrators in improvements of road links. The input data is collected using output data generated by GPS technology, GIS based supportive approach data and field surveys. The study is initiated with supply system. The spatial evaluation is assumed to be proxy to the operational performance evaluation of the network. These characteristics
are often close to ideal in CBD areas which are subjected to constant transformations in functionality of the road systems and are regularized with respect to supply system.

The proposed plan for the reduction and mapping of risk needs huge investment and careful road auditing for implementation at the field level, a short term plan for improvement in the operational performance to prioritize the existing functional roads based on the congestion criteria is suggested using the principal component analysis and causal techniques. The correlation parameters between the observed field data and prioritization observed from the model indicate that the critical links identified in the network through the analysis. These links are the worst links with respect to geometric, traffic, land-use characteristics. This method of analysis is used for the development of the road links and the places where there is more congestion with limited budget constraints, and it serves as a promising role for the road administrators and the government to implement at field level.

The research provides a new dimension for the urban congestion policies, the strategies for achieving the objectives and the implementation techniques at field level. It also provides an innovative understanding of the supply infrastructure in terms of demonstrating in a scientific way. Some trajectories perform better than others according to the analysis. Engineers, planners and policy makers are advised to plan according to control measures for major risk
distributors and major risk generated nodes which is to ensure effective flow of traffic with less delay and congestion in the city.

Research design developed in this study is limited to consolidating the risk quantification and identification of quantifiable role of each factor of influence on urban risk of travel. Prioritization of urban corridors for generating planning policies on urban infrastructure, land use or road side characteristics policies and traffic management plans over a time and space. Apart from this study on a continuation of research, it is needed to analyze the total network on single entity and develop an approach with multi-criteria framed levels of planning. The factors of influence and risk representation should be handled simultaneously in order to prioritize the planning policies on infrastructure and land use. Further certain methodologies should also be developed on integrated frame for sensitive land use planning of infrastructure and traffic mobility system. It is also found that there is a need to further identify research models beyond the operational models like transitional models for dealing with the uncertain issues which are most common phenomenal feature in urban travel demand dealing with the uncertainty under different steady and unsteady states like models of Markov chains heuristic algorithms/ knowledge based expert system trained/untrained knowledge cells in neural networks.