Chapter-2

LITERATURE REVIEW

Traffic congestion is a temporal condition on networks that occurs as utility increases, and is characterized by slower speeds, longer trip times, and increased queuing. When volume of traffic is high and so heterogeneous that the interaction between vehicles slows down the speed of traffic, traffic congestion is the result. As demand approaches the capacity of a road (or of the intersections along the road), traffic congestion sets in. When vehicles are fully stopped for the period of time, this is colloquially known as a traffic jam.

2.1 EXISTING STUDIES ON RISK PARAMETERS

A simple model was developed by Jack Mallinckrodt, 2009 on regional average congestion delay, in a closed-form, differentiable function of regional transportation system with volume and capacity data. This model can be used to reduce the risk generated due to congestion [45].

Different views were studied by Robert A. Johnston, Jay R. Lund, Paul P. Craig, 1995 on congestion generation and degeneration. Their study revealed that, it is unlikely that roadway construction or vehicle automation will be able to alleviate most major urban congestion in the near future i.e. for another 5 –15 years. Traffic congestion occurs when a volume of traffic or modal split generates demand for space greater than the available road capacity. There are a number of specific circumstances which cause or aggravate congestion; most of
them reduce the effective capacity of a road at a given point or over a certain length, or increase the number of vehicles required for a given volume of people or goods. Capacity allocation studies reveal that approaches like laissez-faire allocation, allocation by passenger load, ramp metering, road and parking pricing, allocation by trip purpose, rationing, and mixed strategies can be used for reducing congestion [66].

Quantification of congestion can be done by incorporating the volume and operational characteristics of traffic movement. Bhargab Maitra, P.K.Sikdar and S.L.Dhingra, 1999 conducted a study on quantification of congestion. Quantified congestion level can be used as a logical and improved measure of effectiveness to account for the conceptual definition of level of service in a quantitative manner. Modeling congestion has provided a quantitative basis for understanding the contribution of different vehicle types in overall congestion, and it is useful for evolving the policy for congestion mitigation [13].

The principles of duration modeling can be used to find the extent of congestion. An approach is found for estimating the duration of congestion on a given road section and the probability that, given its onset, congestion will end during the indentified time period. It was studied by Anthony Stathopoulos and Matthew G.Karlaftis, 2001[6].

Evaluating the efficacy of Intelligent Transportation Systems (ITS) technologies in reducing accidents that affect research development of models (such as incident delay and congestion models) that can
accurately predict incident duration along with the magnitude of nonrecurring congestion, have been reported by A.Garib, A.E.Radwan & H.Al-Deek, 1997 [7].

An analysis of freeway traffic flows under congestion was conducted by Do.H.Nam and Donald R.Drew, 1998, based on the principle of traffic dynamics, using the example of recurring congestion [28]. Traditional incident-detection algorithms were developed by Chien-Hua Hsiao, Ching-Teng Lin, Michael Cassidy, 2006 to distinguish between congested and uncongested operation by comparing measured traffic-stream parameters with predefined threshold values [17].

Risk management is a key issue in project management. The first step of risk management is risk identification. It includes the recognition of potential risk causative factors and the clarification of risk. It was studied in detail by Ming-The Wang, Hui-yu Chou, 2006 [60]. Intelligent Transportation Systems are undergoing a transition from demonstration projects to becoming part of the mainstream set of options available to transportation planners. Hence, evaluation of it is one of the most critical and important steps to be taken before any ITS technique can be deployed. Safety has been recently emerging as an area of increased concerns, attention and awareness within transportation engineering [75]. Even though recent studies shed some light on driving speed factors as well as on the direction of the effects, knowledge is still insufficient to allow for specific
Congestion leads to risk and finally may lead to accidents where urban accidents have the highest percentage impact (75%) over the entirety of accidents; therefore they represent a crucial event which potentially may lead to disastrous consequences. Artificial Intelligence may be helpful for providing more powerful techniques to understand the main causes of accidents and congestion. Accident prediction models were developed by Rahim F. Benekohal, Asma M. Hashmi, 1992. Accident prediction models or the before-and-after study approach is commonly used to estimate the reduction in number of accidents resulting from highway improvements [68]. Bin Yuan and Wen-Hua Song, 2007 conducted a study on exploring and accomplishing road traffic safety and rescue system based on 3S technology, which will provide effective instruction platform for traffic instruction department.

Traditional black-spot programs were developed by Tarek Sayed and Walid Abdelwahab, 1997. They aim at improving highway safety and locations, they identified as accident prone based on the total number of accidents [84]. Incidents, defined as unplanned events that temporarily reduce roadway capacity, contribute significantly to urban freeway congestion. Transportation agencies have developed incident management programs in order to support the effective identification and response to incidents. It is expressed by Brian L. Smith, Ling Qin, Ramkumar Venkatanarayana, 2003) [15].
Traffic research still cannot fully predict under which conditions a "traffic jam" (as opposed to heavy, but smoothly flowing traffic) may suddenly occur. Traffic congestion is a universal constant. Some cities have managed to break free of their dependence of the automobile. Many more haven’t, and have lost themselves to congestion. The approach each city takes to the problem of urban congestion and transport is an insight into their priorities and a gauge of how successful their efforts will be. The urban growth and future trends in urban development should be major factors in any urban congestion and transport decision.

Now-a-days urban transport planning is not taking into account the increasing number of motor vehicles, the growth of the city or the environment. Given the enormous benefit to the health of every citizen, in terms of cost and in terms the benefits arising from inner-city accessibility one would think that network functionality and successive planning of public transport would be one of the provincial government’s primary areas of interest. The provincial government is interested, and committees are being set up and meetings are held. But these seek to “solve” congestion when, in reality, it can only be dealt with and this approach to the issue, glaring oversights are common.

For the present study, risk analysis has been proposed to be achieved 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.
2.2 GEOGRAPHIC INFORMATION SYSTEM (GIS)

GIS is a computer-based tool for mapping and analyzing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies (Moses Santhakumar, 1998)[78]. GIS store information about the world as collection of thematic layers which can be linked together by geography. This is a simple but extremely powerful and versatile concept has proven invaluable for solving many real-world problems from tracking delivery vehicles, to recording details of planning applications, to modeling global atmospheric circulation. GIS allows us to bring all types of data together based on the geographic and location component of the data. But unlike a static paper map, GIS can display many layers of information that is useful to us (www.esri.com). Using this, one will be able to integrate, visualize, manage, solve, and present the information in a new way. Relationships between the data will become more apparent and the data will become more valuable. GIS gives us the power to create maps, integrate information, visualize scenarios, solve complicated problems, present powerful ideas, and develop effective solutions like never before.
2.3 STUDY OF RISK CRITERIONS

As discussed in the previous chapters, to identify the exact criterions and the links which lead to congestion and to study which are the real factors of risk generation, certain criterions have been identified. The broad criterions are categorized in four groups – Geometric characteristics, Traffic characteristics, Land use or roadside characteristics and Utility characteristics. The attributes considered under each criterion are as follows.

Geometric characteristics

Geometric characteristics represent the geometric features of the roadway affecting the Level of service of the link. These are the static characteristics of the road infrastructure.
1. Roadway width in meters (RW)
2. Carriageway width in meters (CW)
3. Stopping sight distance in meters (SSD)
4. Number of curves on the link (NC)
5. Pavement Condition index determined from the rating of the pavement based on the pavement condition and riding comfort experienced by the user on a scale of 1 to 5, 5 being excellent pavement and 0 being an impassable pavement (PCI). Pavement condition index is quality and comfort promoted on a pavement with defined mobility speed of 20 kmph. The pavement condition is assessed with cumulative bumps occurred in the travel with bump integrator machine. If the bump depth in a one km length is between 0 to 50 mm it is ranked as 5 and beyond 250mm per km it
is ranked as 0. The transitional ranking of 4, 3, 2, 1 is given in proportion in the range of bump depth 50 and 250mm.

The geometrics of highway should be designed to provide optimum efficiency in traffic operations with maximum safety at reasonable cost. The overall design of geometrics of a highway is a function of the design speed. Geometric attributes are studied from static data. They are collected from satellite data by using GPS and GIS as supportive tools and field survey data.

**Traffic characteristics:**

Traffic characteristics are the dynamic characteristics of the road that influence the level of service of the link. They are

1. Headway in seconds (H)
2. V/C Ratio (VCR)
3. Intensity of Parking (PBE), business activities and road side activities encroachments in a point scale.
4. Speed in kmph (V)
5. Delay in seconds (D)

The traffic characteristics are quite complex with various types of road users in the roads moving with different motives. Study of vehicular characteristics is an essential part. Apart from these, the various studies to be carried on the actual traffic include traffic flow characteristics.
Traffic studies

Traffic studies or surveys are carried out to analyze the traffic characteristics. These studies help in deciding the geometric design features and traffic control for safe and efficient traffic movements. The traffic surveys for collecting traffic data are also called traffic census.

The various traffic studies generally carried out are

- Traffic volume study
- Speed Studies
- Traffic flow characteristics
- Traffic capacity study
- Parking study
- Head way study

Traffic Volume Study

One of the fundamental measures of traffic on a road system is the volume of traffic using the road in a given interval of time. It is also termed as flow and it is expressed in vehicles per hour or vehicles per day. When the traffic is composed of a number of types of vehicles, it is the normal practice to convert the flow into equivalent passenger car unit (PCUs) by using certain equivalency factors. The flow is then expressed as PCUs per hour or PCUs per day.

Manual methods use field personnel to count and classify traffic flowing past a fixed point. Some of the advantages of manual methods and situations where these are to be preferred are
• Details such as vehicle classification and number of occupants can be easily obtained.

• The data can be collected giving the breakdown of traffic in each direction of travel.

It is more desirable to record the traffic in both the directions of travel separately and post separate observations for each direction. For all day counts, work in three shifts of 8 hours each could be organized. A separate observer is needed if the occupancy count is to be made.

**Parking Usage Survey**

The purpose of usage survey is to obtain data on the extent of usage of parking spaces. The survey will include counts of parked vehicles at regular intervals through a period, covering both morning and evening peak period, and the parking accumulation and turn over.

**Speed Survey**

Speed is one of the most important characteristics of traffic and its measurements are a frequent necessity. All vehicles do not travel at the same speed at a location along a road. The amount of speed dispersion or the spread from the average speed affects both capacity and safety. Actual speed of a vehicle over a particular route may be fluctuating widely depending on several factors such as geometric features, traffic conditions, time, place, environment and driver. Speed studies carried out occasionally give the general trend in speeds.
**Speed and Delay Study**

The speed and delay studies give the running speeds, overall speeds, fluctuations in speeds and the delay between two stations of a road spaced far apart. They also give the information such as the amount, location, duration frequency and causes of the delay in the traffic stream. The results of the speed and delay studies are useful in determining the spots of congestion, the cause and in arriving at a suitable remedial measure.

**Delay Studies**

Delay studies along routes are best done by the moving observer method described earlier. The delays occurring due to stopping can be conveniently recorded by separate stop watch. Special watches which can accumulate the delay time as the observer operates buttons will be found convenient for this purpose. The delays that can be measured thus are stopped delays or fixed delays which occur at intersections, railway crossing and stop signs.

**Land use or Road side Characteristics**

These are also the static elements of the link which influence the operational efficiency of the link. They are:

1. Number of access points on the link (NA)
2. Commercial area along the road side of the link in sq km (CA)
3. Residential area along the road side of the link in sq.km (RA)
4. Semi Residential area along the road side of the link in sq .km (SRA)
5. Industrial area along the road side of the link in sq .km (IA)
These are static elements of the link which influence the operational efficiency of the link. The data is collected from satellite, field and from municipality authorities.

**Utility characteristics**

Utility characteristics are the characteristics of the link indicating the degree of utility of the link with reference to the static analysis and dynamic analysis.

1. Overlap size of the link from static analysis (OS)
2. Trip intensity on the link (TI) in trips / day

Utility characteristics of the link indicate the degree of utility of the link with reference to the static and dynamic analysis. Utility characteristics are collected from field and OD survey.

**Origin and Destination Studies**

The origin and destination (O & D) study is carried out mainly to plan the road network and other facilities for vehicular traffic and plan the schedule of different modes of transportation for the trip demand of commuters. The present study is proposed to adopt Road side interview method for collecting the origin and destination data.

Road side interview survey is one of the methods of carrying out a screen – line or cordon survey. The road side interview survey can be done by directly interviewing drivers of the vehicles at selected survey points. For dual carriageway or roads with very little traffic, the traffic in both the directions is dealt with simultaneously. In other cases the traffic in two directions will be monitored at different times.
It is impractical to stop and interview all the vehicles. Sampling is therefore necessary. The number of samples depends on the number of interviewers and the traffic using the road. The analysis of the data by computers will be easy. Since the interview is done by sampling basis, expansion factors are needed to calculate the total number of trips. These expansion factors will be calculated separately for each class of vehicle and for different time periods (half – hour etc). Road side interview is an economic method of survey and yields accurate and reliable data.