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# REMEDIAL MEASURES OF TRAFFIC CONGESTION FOR CBD AREA

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**Abstract:** Traffic congestion has been one of major issues that most major cities are facing. It is believed that identification of congestion is the first step for selecting appropriate mitigation measures. Congestion - both in perception and in reality - impacts the movement of people. Traffic congestion wastes time, energy and causes pollution. There are broadly two factors, which effect the congestion; (a) micro-level factors (b) macro-level factors that relate to overall demand for road use. Congestion has clearly grown. Congestion used to mean it took longer to get to/from work in the "rush hour." But congestion now affects more trips, more hours of the day and more of the transportation system. Paper provides an overview of congestion in India by summarizing recent trends in congestion, presents the possible ways to identify and measure metrics for urban arterial congestion, highlighting the role of unreliable travel times in the effects of congestion, and describing efforts to curb congestion.

**Keywords:** Traffic congestion, Remedial measure for traffic.

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## INTRODUCTION

**Concept of congestion: (**In perception and in reality**)** Traffic congestion has been one of major issues that most metropolises are facing and thus, many measures have been taken in order to mitigate congestion. It is believed that identification of congestion characteristics is the first step for such efforts since it is an essential guidance for selecting appropriate measures. Congestion - both in perception and in reality - impacts the movement of people and freight and is deeply tied to the history of high levels of accessibility and mobility. Traffic congestion wastes time and energy, causes pollution and stress, decreases productivity and imposes costs on society.

There are two principal categories of causes of congestion, and they are; micro-level factors (e.g. relate to traffic on the road) and macro-level factors that relate to overall demand for road use. Congestion is "triggered" at the "micro" level (e.g. on the road), and "driven" at the "macro" level by factors that contribute to the incidence of congestion and its severity. The micro level factors are, for example, many people and freight want to move at the same time, too many vehicles for limited road space. Many trips may be delayed by events that are irregular, but frequent: accidents, vehicle breakdowns, poorly timed traffic signals, special events like mass social gatherings, political rallies, bad weather conditions, etc. which present factors that cause a variety of traffic congestion problems. On the other side, macro level factors e.g. land-use patterns, employment patterns, income levels, car ownership trends, infrastructure investment, regional economic dynamics, etc. also may lead to congestion.

This paper discusses the existing practices in different countries, the contributions by individuals and prevailing methodologies for measurement of the congestion along with the critical review of the methods. Review has also been done with reference to Indian conditions. The critique and the suggested methodology may be useful for similar developing countries.

$$\text{Travel Time Index} = \frac{\left(\frac{\text{Freeway Travel Rate}}{\text{Freeway Free-flow Rate}} \times \text{Freeway Peak Period VMT}\right) + \left(\frac{\text{Principal Arterial Street Travel Rate}}{\text{Principal Arterial Street Free-flow Rate}} \times \text{Principal Arterial Street Peak Period VMT}\right)}{\left(\text{Freeway Peak Period VMT} + \text{Principal Arterial Street Peak Period VMT}\right)}$$

## II. LITERATURE REVIEW

The level at which transportation system performance is no longer acceptable due to traffic interference." Because there is a relative sense to the word "congestion," the FHWA continues their definition by stating that "the level of system performance may vary by type of transportation facility, geographic location (metropolitan area or sub-area, rural area), and/or time of day," in addition to other variations by event or season. In Washington D.C. in year 2002, it was estimated that congestion "wasted" $63.2 billion in 75 metropolitan areas because of extra time lost and fuel consumed, or $829 per person were wasted.[1]

The demand for mobility has risen significantly all over the world as a result of the fast pace of urbanization. The situation is no different in India. In India, personal vehicles have increased tremendously to take care of this rising need for mobility as provision of public transport has been in adequate. India has more truly congested cities than any other nation, which is not surprising, since it is also the world'ssecond-most populous country, after China. Vehicles in India are distributed somewhat unevenly. Delhi, Mumbai, Kolkata and Bengaluru have 5% of India's population but 14% of its registered vehicles. Traffic is growing four times faster than the population in six cities: Mumbai, Delhi, Ahmedabad, Bengaluru, Chennai and Hyderabad. Indeed, Traffic is well known for moving at the pace of its slowest component. Most countries have automobiles, buses, trucks, trains, motorcycles, motor scooters and bicycles. But in India, in addition to this routine urban transportation, and contributing substantially to the congestion, are networks of auto-rickshaws and two-wheelers, as well as bullock carts and hand-pulled rickshaws (disappearing from some urban areas). There has been a staggering 100fold increase in the population of motorized vehicles; however, the expansion in the road network has not been commensurate with this increase.

This exponential growth of vehicles has led to traffic congestion which is a hindrance to mobility. Traffic congestion leads to increase in operating cost of vehicles, delay, pollution and stress. The problem is acute in the Indian city of Kolkata as the road space here is only 6% compared to 23% in Delhi and 17% in Mumbai.[2]

## III.METHODS FOR CLASSIFICATION

Congestion measurement methodology should have the following characteristics: (a) It should be simple to understand and unambiguous; (b) It should have the ability to describe the existing traffic conditions and predict the future changes; (c) It should have an ability to apply statistical

techniques, replicability of the results with a minimum of data collection; (d) The methodology should have applicability to various modes, facilities and time periods.

**Travel Time Index (TTI)** is a comparison between the travel conditions in the peak period to free-flow conditions. It uses the units of travel rate (the inverse of speed) due to the ease of mathematical calculation and availability of data elements in both traffic surveillance and roadway inventory databases. The equation below presents the calculation of the travel time index for areawide applications.

The index can be applied to various system elements with different free-flow speeds. The travel time index compares measured travel rates to free-flow conditions for any combination of freeways and streets. Index values can be related to the general public as an indicator of the length of extra time spent in the transportation system during a trip.

The **Buffer Time Index (BTI)** expresses the amount of extra "buffer" time needed to be on-time 95 percent of the time (late one day per month). Indexing the measure provides a time and distance neutral measure, but the actual minute values could be used by an individual traveler for a particular trip length. The index is calculated for each road segment and a weighted average is calculated using vehicle-miles of travel as the weighting factor.

$$\text{Buffer Time Index} = \text{Weighted Average of All Sections (Using VMT)} \left[ \frac{\text{95th Percentile Travel Rate (in minutes per mile)} - \text{Average Travel Rate (in minutes per mile)}}{\text{Average Travel Rate (in minutes per mile)}} \times 100\% \right]$$

The **Planning Time Index (PTI)** is simply the 95th percentile travel time index. It is used as a supplemental measure for reliability. Because reliability is related to the distribution of travel rates, the 95th percentile indicates an excessively high travel rate, one that only five percent of all travel rates exceed for the time period under consideration.

**Delay** is the amount of extra time spent in congestion compared to the time it would take under ideal or free-flow conditions. For example, if a trip takes 10 minutes under ideal conditions, and during the peak it takes 15 minutes, the total amount of delay is five minutes.

**Speed**

The literature has suggested several speed measures besides average travel speed. Theaverage travel rate, in minutes per mile, is the reciprocal of average travel speed. Peak period nominal speeds are a weighted average of speeds on freeways and principal arterial streets, which allow comparison of the freeway and principal arterial street network between urban areas. Theratio

of peak period to off-peak period speed suggested as direct measures of congestion. Some of the approaches based on speed are described below.

**Empirical Relationships**

Several of the early efforts in congestion measurement centered on empirical relationships that attempted to incorporate driver effort and satisfaction into an index of the quality of traffic flow. The quality of traffic transmission index (Q index) was defined as a function of average speed and the number and sum of speed changes.

$$Q = \frac{KS}{\triangle s\sqrt{f}}$$

Where,

Q - Quality of traffic transmission index,

K -1000 (constant),

S - Average speed (mph),

$\triangle$s- Absolute of speed changes per mile, and

f - Number of speed changes per mile.

**Travel Time**

The use of travel time studies and related measures to describe system performance and congestion permeated the traffic engineering literature as early as the late 1920s. The early studies concentrated on determining average travel speeds in congested downtown areas and attempted to locate the magnitude and sources of travel delay. Some of the indices related to travel time are listed below

**Travel Time Index (TTI)**

Travel Time Index was proposed in the Urban Mobility Report. Index compares peak period travel and free flow travel while accounting for both recurring and incident conditions. This index is expressed by comparing travel time in free flow condition and the one in peak hours. Index has the advantage of expressing traffic congestion in terms of both space and time:

$$TTI = \frac{(Peak\ period\ traveltime)}{(Free\ flow\ travel\ time)}$$

Where, TTI- Travel time index.

**Travel Rate Index (TRI)**

This index computes the "amount of additional time that is required to make a trip because of congested conditions on the roadway." It examines how fast a trip can occur during the peak period by focusing on time rather than speed. The TRI is an indicator for entire portions of the analyzed network based on the respective distance and number of vehicles supported by each section.

**Buffer Index**

The buffer index calculates the extra percentage of travel time a traveller should allow when making a trip in order to be on time 95% of the time. This method uses the 95th percentile travel rate and the average travel rate, rather than average travel time, to address trip concerns. The buffer index represents the reliability of travel rates associated with single vehicle. This measure may be beneficial to the public because it tells them how congestion will affect them as individuals.

In addition to above, there are few more indices like Misery Index, Travel rate, Congested travel, Congested roadway, Accessibility, Congestion Index also available based on the travel time.

**Level of Service**

Traditionally, the use of level of service (LOS) has been one of the most popular measures of traffic congestion which represents a range of operating conditions. Volume to capacity ratio can provide a good measure of the volume compared to capacity of the roadway under existing and future conditions. Therefore, volume-to capacity can be used as a measure of future performance through basic calculations using available data. Where accurate future land use data is available, growth can be estimated based on anticipated development activity versus anticipated growth rates. Volume to capacity ratios could be compared to LOS to reach conclusions about congested conditions. Some of the congestion indexes, which works based on level of service etc.

## IV. EXISTING PRACTICES IN DIFFERENT COUNTRIES

### United States of America

The United States have systematic programmes to identify the traffic congestion and to handle the congestion problems. California Department of Transportation (Caltrans):Caltrans defines congestion as occurring on a freeway when the average speed drops below35 mph for 15 minutes or more on a typical weekday (Varaiya, 2001) [3]. In Minnesota, freeway congestion is defined as traffic flowing below 45 km/h for any length of time in any direction, between 6:00 a.m. and 9:00 a.m. or2:00 p.m. and 7:00 p.m. on weekdays. Michigan defines freeway congestion in terms of LOS F, when the volume/capacity ratio is greater than or equal to one. Denver Regional Council of Governments examines traffic congestion (DRCOG, 2011) by studying the regional vehicle miles travelled measures and regional freeway bottlenecks time to time and discuss the key reasons for the bottleneck, possible mitigation strategies and congestion measurements. Council monitors various congestion measures like: Vehicle Miles and Hours of Travel, Average Travel Speed (mph), Person Miles of Travel (VMT), and Person Hours of Travel, etc. The council's web site is operational and available for public use and review. Web site displays the congested corridor if the speed on the corridor is less than 15 mph. The greater Montréal considers the vehicle have joined a highway queue when its speed drops below 25 km/h and is considered to have left the queue when its speed rises above the 60 km/h mark. Rhode Island State DOT attempts to use objective congestion performance measures such as percent travel under posted speed and volume/capacity ratios.

### South Korea

In South Korea there are several agencies involving the operation of traffic flow. Korea Highway Corporation (KHC) identifies traffic congestion spots where vehicle speeds fall below 30 km/h or traffic congestion continues longer than 2 hours a day with occurring10 days a month. Daejoin city ITS center following the congestion criteria at vehicle speed less than 14 km/h.

### Japan

Japan uses the speed as threshold value to identify the potential traffic congestion areas. It is said traffic congestion if freeway travel speed falls below 40 km/h, if there are repeated 'Stop-and-Go' flows for more than1 km, or if these conditions stay more than15 minutes.

**India**

Traffic congestion is a major problem for transportation professionals in India. Most of the cities are suffering from medium to high level of traffic congestion. Although in some major cities the growth of private vehicle usage has increased at a faster rate, in general, car ownership and usage has remained at a much lower level in Indian context. The poor roadway condition, non-uniform roadway features in terms of carriageway and shoulder width, encroachment of road, abutting land use and resulting pedestrian activities, poor lane discipline, improper bus stop location and design, vehicles of wide ranging characteristics of technology and operating condition, heterogeneity of traffic, uncontrolled on-street parking, etc. indicate that the nature and cause of congestion in India might be substantially different from that in the developed countries.

Although the roads are becoming at a fast rate, there has been no serious attempt to quantify the growth of congestion in different cities in India. The non-availability of funds for additional roadway infrastructure has seriously constrained the growth of the supply side.

Amudapuram Rao and KalagaRao[4] discuss an interesting way of detecting the congestion on the urban roads in India. They suggest using emitting device compromising Wi-Fi and a receiver present across the road to identify the congestion. In terms of high accuracy of classifying the road, this method was found successful as to know that roads are congested or free flowing. To cater the traffic conditions and congestion in developing regions, ITS techniques that need to be developed, that are presented with few efforts made in this direction. Merugu et al. [5] discuss the project involving 14,000 employees of Infosys INSTANT (INfosys-STAN ford Traffic project) where project carried out for six months from Oct 6, 2008, to April 10, 2009.

The aim of the project is providing in centivestodecongestors. The project succeeded in incentivizing many commuters to travel at uncongested times, thereby significantly reducing their commute times. Dewan and Ahmad [6] conducted a survey for car-pooling in Delhi and willingness of commuters for car pooling and they observed that car-pooling is one of the solutions to reduce the traffic congestion in Delhi. Many ITS applications have already been designed, implemented, deployed and are being used in developed countries. But there are some major differences between the road and traffic conditions that are prevalent there and in India. For e.g. in USA, freeways and expressways extend to over 75,000 kms, while claims that only about 200 kms of expressways are present in India. Also Indian traffic is highly disorderly and chaotic. Roads are also generally not as well maintained, with potholes being common. Thus it is intuitive that the various techniques that have been developed in the context of traffic conditions in developed countries will not be applicable directly in an Indian context [7].

## V.TRENDS AND SOURCES OF CONGESTION

There are several statistics that point to worsening congestion levels. Congestion extends to more time of the day, more roads, affects more of the travel, and creates more extra travel time than in the past. And congestion levels have risen in cities of all sizes since 1982, indicating that even the smaller areas are not able to keep pace with rising demand.

Figure 1 illustrates trends for 75 major urban areas tracked in the Texas Transportation Institute's Annual Mobility Report. Congestion levels have risen to

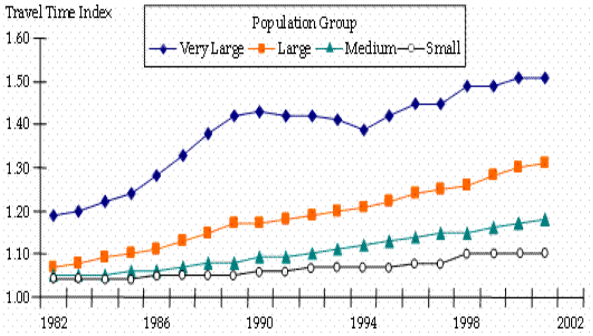


**Fig. 1Peak-Period Congestion (Travel Time Index) Trends by U.S. Population Group.**

levels experienced by the next largest population group every 10 years in 2001, cities between 500,000 and one million people experienced the congestion of cities between one and three million in 1992.

The Travel Time Index is a measure of the total amount of congestion. It is the ratio of the weekday peak-period travel time to the travel time under ideal conditions. A Travel Time Index value of 1.3 indicates that peak-period travel takes 30 percent longer than under ideal conditions. Population groups are: Very Large (greater than three million); Large (one to three million); Medium (500 thousand to one million); Small (less than 500 thousand).

Congestion has clearly grown. Congestion used to mean it took longer to get to/from work in the "rush hour." But congestion now affects more trips, more hours of the day and more of the transportation system.

### Sources of congestion and unreliable travel

Congestion is a lot more complex than simply "too many vehicles trying to use the road at the same time," although that is certainly a major part of the problem. Congestion results from the

interaction of many different factors - or sources of congestion. Congestion has several root causes that can be broken down into two main categories:

**Traffic-influencing events** – In addition to the physical capacity, external events can have a major effect on traffic flow. These include traffic incidents such as crashes and vehicle breakdowns; work zones; bad weather; special events; and poorly timed traffic signals. When these events occur, their main impact is to "steal" physical capacity from the roadway. Events also may cause changes in traffic demand by causing travelers to rethink their trips (e.g., snow and other types of severe weather).

Only recently has the transportation profession started to think of congestion in these terms. Yet it is critical to do so because strategies must be tailored to address each of the sources of congestion, and they can vary significantly from one highway to another. Nationally, a composite estimate of how much each of these sources contribute to total congestion is depicted in Figure 2.

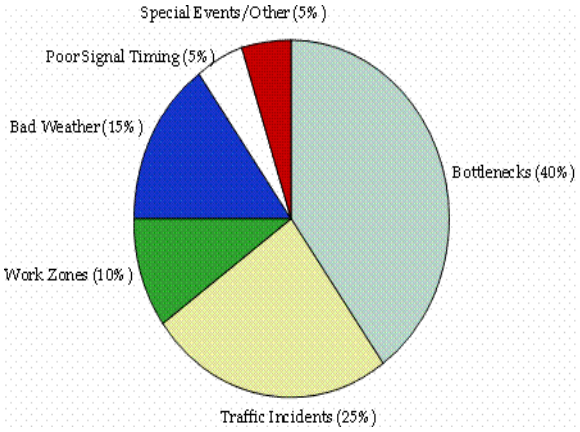


**Fig.2 Traffic caused due to different events**

## VI. REMEDIAL MEASURES FOR TRAFFIC CONGESTION

Transportation engineers and planners have developed a variety of strategies to deal with congestion - a toolbox for managing congestion. The strategies can be grouped as follows:

- ✓ Adding more capacity for highway, transit and railroads;

- ✓ Operating existing capacity more efficiently; and
- ✓ Encouraging travelers to use the system in less congestion-producing ways.

Each of these congestion reducing strategies has a role in major cities. More accurately, they all have a role in some locations and corridors within major cities. Implementing the strategies involves consideration of the size and type of problem, funding, and public approval, environmental and social consequences. The decisions resulting from all these factors will be different, diverse and reflect local, state, and national priorities. When used in combination, however, the strategies can have a powerful impact on congestion growth. Also, when applying these strategies, agencies need to think and act regionally about solutions to congestion problems. In fact, FHWA is promoting the concept of regional partnerships as a means to implementing effective operations. These partnerships provide a platform for interagency coordination and joint delivery of operations-based services.

Some of the measures to reduce traffic congestion are as follow:

**Identify the congestion problems and opportunities** – Both technical analyses and anecdotal information from the public are useful in identifying where the major congestion problems are, where they will be, and what causes them. The existing transportation planning process in metropolitan areas can be tapped as a resource for this purpose. Thoroughly analyze and provide realistic assessments on what can reasonably be done in each case, and what the expected improvements might be. FHWA supports a wealth of information on expected improvements from operational strategies, such as the ITS Benefits and Cost Database

**Develop plans, programs, policies, and projects** – Congestion solutions can take a variety of forms. Think broadly - no single tool will be highly effective against the congestion problem. But when used in combination and tailored to specific circumstances - packages of congestion mitigation strategies can be successful. The strategies should include action elements - things we can accomplish in a short timeframe and at low cost. But longer-term actions also should be developed with considering all types of strategies including adding new highway and rail capacity, improved operations, and better land use planning. Recognize that many transportation and community plans already exist and should be tapped as mechanisms for carrying out the Vision. In fact, acting on a list of "things we can do now" should help galvanize support for congestion mitigation over the long term.

**Plan, manage, and operate the transportation system proactively and regionally-** Focus on addressing system reliability by targeting capital and operations strategies to specific conditions. Anticipate problems and take corrective actions early. Also, regional and multimodal cooperation is the key to the success of deploying effective operations. Many different agencies have a stake in the congestion problem. Therefore, a broad perspective should be taken in applying capital and operational strategies - avoid a narrow, facility-oriented view.

**Use performance measures to track progress** - One of the main actions that transportation agencies can contribute is the tracking of congestion trends and the effect of improvements over time. Trends provide a basis for determining how well your actions are working and can identify changes in the underlying congestion problem (e.g., traffic crashes may become more important in your area). Use of performance measures also brings an element of **accountability** to the process.

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