A REVIEW ON EFFECTIVE SOLUTION OF TRAFFIC CONGESTION ISSUES OCCURRING IN THE URBAN AREAS

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Abstract - The exponential growth of road traffic in recent years has produced problems such as congestion, delays, accidents, and environmental degradation. Traffic congestion is a true nuisance to the society that affects both developed and developing countries. It affects both personal and public transportation passengers, and develops numerous negative social consequences in addition to diminishing economic efficiency. This paper presents a review of various factors related to traffic congestion, responsible for congestion are identified and impacts of congestion are presented. Major methodologies and remedial measures adopted by various researchers and government are reviewed. It is concluded that the most common factor responsible for congestion is the increase in the number of private vehicle ownership per km road stretch or per million population around the world. Vehicle to road capacity ratio, poor geometrical features, poor lane discipline, insufficient capacity of road for peak hour traffic, road side parking, poor urban system planning etc., are the main factors identified causing the congestion problem. Congestion's most visible effect is an increase in travel time, especially during peak hours. Furthermore, the slow pace of circulation irritates drivers and causes them to act aggressively. It also increases environmental issues and causes health problems. This review paper seeks positive results towards reduction of congestion, travel time delays and more efficient traffic flow on urban roads.

***Key Words*: Traffic Congestion, Mobility, Traffic Flow, Delay, Geometry, Jam Density.**

1. INTRODUCTION

Due to numerous drawbacks like slower speeds, longer travel times, and increased vehicle queuing, traffic congestion has been a major bother around the world. Traffic congestion on urban road networks has increased substantially since the 1950s [1]. Congestion generally occurs due to increased traffic volume per lane, which resulted a reduction in vehicular speed. The new traffic demand is beyond the capacity of the existing infrastructure. The restriction of the area per lane and activities along the roadside also have an impact on the efficient movement of traffic. Due to traffic congestion, a significant amount of working hours are lost on the roads, which has a detrimental impact on the economy as a whole. India, one of the world's most rapidly developing countries, has a very large number of both public and private automobiles [2]. Traffic control in India has always been a difficult task. The heterogeneous conditions of traffic with poor lane discipline in India worsen the congestion. Therefore, it becomes necessary to find out the solution to congestion problems of various Indian cities. However, both known and unpredictable events are linked to traffic congestion. Unpredictable factors include weather conditions, accidents, and driver behavior. Predictable factors include road construction sites or peak travel times (such as office hours), which drivers are aware of. If drivers are aware of these traffic bottlenecks beforehand, congestion caused by the factors mentioned can be avoided. Poor road conditions, poor lane discipline, uneven carriageway and shoulder widths, encroachment of the road, misuse of the land and the resulting pedestrian activities, heterogeneity of traffic, uncontrolled on-street parking, improper bus stop location and design, vehicles with a wide range of technological and operational characteristics etc. suggest that the nature and cause of congestion in India may be significantly different from that in the developed countries [2]. Recurrent and non-recurrent traffic are two of the many forms of traffic. Over time, patterns of congestion are brought on by recurrent traffic. As an illustration, consider the rush hours in the morning and evening, which recur every weekday in accordance with school and office hours. Non-recurring traffic jams occur suddenly and without a repeating pattern. Examples include traffic congestion caused on by the worst weather, public rallies, social gatherings, and accidents and vehicle breakdowns. Whether it is recurring or not, it must be monitored and measures to reduce it need to be implemented [3].

This paper compares several congestion approaches while taking into account the numerous solutions for the congestion problem that have been presented.

1.1 Congestion

Congestion in the context of transportation typically refers to an overflow of vehicles on a section of road at a particular

time, resulting in lowered speeds, sometimes much slower than normal or "free flow" rates. Stopped or stop-and-go traffic is a common sign of congestion. Roads congested with vehicles such as buses, cars, and trucks make it quite simple to spot congestion. What determines congestion affects the approaches taken to reduce it.

No single definition of traffic congestion is universally believed (Downs, 2004). These definitions can be broadly categorized into three groups [4],

1. **Definition on the basis of demand capacity**- Congestion is a condition in which the number of vehicles attempting to use a roadway at any time exceeds the ability of the roadway to carry the load at generally acceptable service levels (Rothenberg, 1985).

2. **Definition on the basis of delay on travel time**- Traffic congestion is a condition of traffic delay (when the flow of traffic is slowed below reasonable speeds because the number of vehicles trying to use the road exceeds the traffic network capacity to handle them (Weisbrod, Vary and Treyz, 2001).

3. **Cost related**- Traffic congestion refers to the incremental cost's resolution from interference among roads users (VTPI,2005).

In general, congestion is the condition of traffic when the traffic volume exceeds the capacity of the lane or roadway for a given period of time. This situation arises due to number of factors such as human behaviour, vehicular traffic, insufficient roadway etc. Congestion has become a serious issue to the urban environment, which is responsible for the occurrence of other problems like pollution, increased travel time etc. Therefore, study of congestion problem becomes very important for an efficient urban development.

2. PROBLEM OCCURS DUE TO TRAFFIC CONGESTION: PERSPECTIVE TO INDIA

India is the world's second-most populous country after China [5]. Indian cities are truly congested than any other nation in the world due to very high number of vehicles. Traffic is well known for moving at the pace of its slowest component. India has heterogeneous traffic, and apart from routine urban transportation, networks of auto-rickshaws and two-wheelers as well as bullock carts, hand-pulled rickshaws contribute substantially to the congestion. Due to lack of connectivity of routes, private vehicle usage is increasing despite of public transportation. It also causes traffic congestion in India. Also, staggering hundred-fold increase in the number of motorized vehicles has made the congestion worse. The motor-vehicle population has grown

from 0.3 million in 1951 to over 295.8 million in 2019. The total length of the country's road network as of March 31, 2019, was 63.31 lakh kilometres. According to the report's research, India had 1,926 km of roads as of the end of March 2019. The density of urban roads is higher in India and has grown over time. By the end of 2011–12, the urban road density was 4,026.12 km per square kilometre; by the end of 2018–19, it had climbed to 5,296.3 km per square kilometre [6].
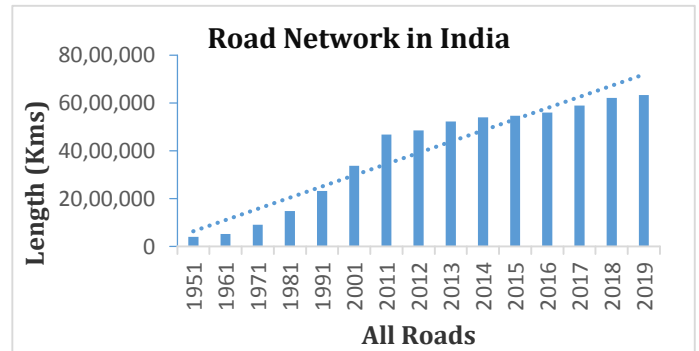

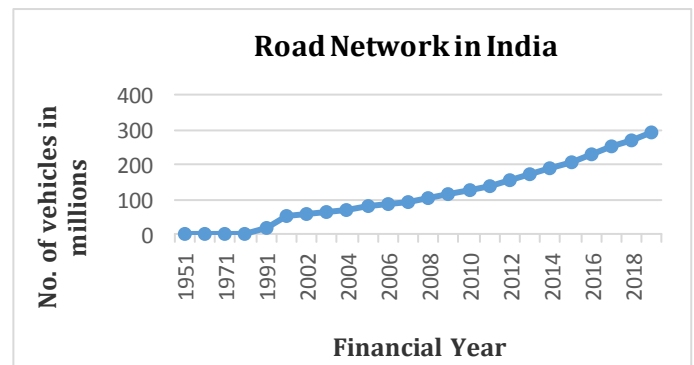**Chart -1:** Stats of Road Length by Categories (in Km) 1950-51 to 2017-19 [6]

Chart -2: Number of vehicles in operation across India from financial year 1951 to 2019(in millions[6]).

Uncontrolled on-street parking, illegal parking, encroachment of main carriageways, poor lane discipline, inadequate facilities for pedestrians, poor quality of public transportation, improper bus stop location and design, vehicles with a wide range of technological and operational characteristics, heterogeneity of traffic, and poor roadway condition are just a few of the major issues that were observed [7].

As we have discussed, congestion has become a major problem and creates day to day challenges. Reasons behind causes of congestion are taken in view and sources are derived.

3. CAUSES OF TRAFFIC CONGESTION

Traffic congestion occurs when the vehicles either come to a complete stop or move below its normal speed. It is not a pleasant situation for anyone. Some of the reasons behind traffic congestion are discussed below [8]:

- **Narrow Roads-** Streets, which are not wide enough due to illegal possession on the road getting narrow and becoming a reason behind traffic jam.

- **Illegal Parking-** Vehicles parked on the road is the reason behind traffic congestion.

- **Population growth-** Increase in population leads to demand of transportation.

- **Higher Public Purchasing Power-**The popularity of private transportation is growing in India as a result of the country's residents' higher purchasing power, but the country's current highways and roads are unable to keep up with the growth in vehicles or adapt to it. Therefore, there is an alarming rise in traffic congestion.

- **Improper city development planning -** While every city has a long-term growth plan, it is not properly done. The majority of the time, roadside land is observed to have been ceased illegally, but because of the vague development plan, these kind of actions are ineffective.

- **Malfunctioned traffic signals-** The outcome of malfunctioning signals is a traffic jam. Due to an inadequate public transit infrastructure, there are too many cars on the roads. Roadblocking obstacles include double parking, road construction, accidents, and more. Overdevelopment in locations with already-congested mass transit systems.There are several disadvantages of congestion such as loss to economy, increase in travel time etc. As the vehicular population is expected to increase exponentially by Therefore, it becomes necessary to understand the factors responsible for congestion.

The U.S. federal highway administration has presented the sources of congestion as follows [9]:

Category 1- Traffic Affecting Events

1. **Traffic Incidents-** Incidents that obstruct the regular flow of traffic, primarily through physical obstruction in the lanes of travel. The most frequent types of occurrences are those involving vehicles, such as collisions, breakdowns, and debris in the lanes of traffic.

2. **Work Zones-** Are on-road construction activities that alter the area around the highway physically. One or more of the following modifications may be made: reduced or narrower driving lanes; lane "shifts" or lane diversions; reduced or no shoulders; or even temporary road closures.

3. **Weather-** Traffic flow may alter as a result of changes in driving behaviour brought on by environmental factors. When there is precipitation, intense sunshine on the horizon, fog, or smoke, drivers will usually drop their speeds and increase their headways due to the poor visibility.

Category 2- Traffic Demand-

1. **Variations in Regular Traffic-** Demand varies from day to day, therefore some days will see higher traffic numbers than others.

2. **Special Events-** Are an unique instance of demand fluctuations where traffic patterns near the event will differ significantly from "usual" trends.

Category 3- Features of the physical highway-

1. **Devices to Control Traffic-** Congestion and travel time variability are also impacted by frequent disruption of traffic flow caused by control devices like railroad grade crossings and improperly timed signals.

2. **Physical Bottlenecks-** The most traffic that a particular highway segment can accommodate. The number, width, and alignment of lanes, shoulders, merge lanes at interchanges, and roadway orientation all affect capacity (grades and curves). Because they impede the actual flow of traffic, toll booths can be seen as a particular type of bottleneck. Various congestion problems have several impacts on traffic.

4. CONGESTION IMPACTS

Slower speeds, lines, and longer travel times are all indications of congestion, which raises economic expenses and has an effect on metropolitan areas and the people who live there. Indirect effects of congestion include those on quality of life, stress levels, and safety, as well as effects on non-vehicular road space users including those who use sidewalks and properties along roads.

The slow moving cars in traffic jams also generate certain hydrocarbons and nitrogen oxides to be released into the air, which is a primary cause of what is known as photochemical smog. The list of effects of congestion from previous studies is shown below [10]:

- Travel time increase.
- Increased fuel usage results in fuel loss.
- Time loss because of unexpected traffic.
- Traffic congestion has an effect on the environment by released harmful gases.
- Shorter lifetime of the road surface.
- An increase in the price of vehicle maintenance as a result of mechanical component wear and tear.
- Impatient drivers may be more likely to drive aggressively and carelessly, which increases the risk of accidents.
- Negative psychological effects on individuals, which may have an influence on interpersonal relationships and work productivity.

In order to reduce the impacts of congestion few measures had been adopted by various researchers and authorities.

5. Measures of Congestion

Congestion is measured and tracked using a variety of performance metrics, but they are all related to the factors that travellers value most: travel time and the daily variations in travel time. Mobility Measures and Reliability Measures are subcategories of Congestion Measures [11].

Mobility Measures

The Team Kentucky Transportation Cabinet has identified the following five as the most typical mobility measures:

- Volume to Capacity Ratio (V/C Ratio): It is volume divided by capacity. Volume is frequently assumed to be the 30th greatest annual volume for the Level of Service (LOS) calculations.

- The Level of Service (LOS): The efficiency of a road or crossroads is graded from A to F, with A denoting unrestricted flow and F denoting extremely congested traffic. Long regarded as the principal indicator of congestion for planning purposes, LOS is based on a volume to capacity (v/c) ratio.

- Travel Time Index: Ratio of the average peak travel time to a free-flow (off-peak) standard, in this example 60 mph on freeways. For instance, a value of 1.20 denotes a 20% longer travel times over off-peak travel times.

- Travel Delay: The additional time required to travel because of congestion.

- Congested Travel Percentage: The ratio of the congestion to the overall vehicle miles travelled. A comparative indicator of the volume of travel impacted by congestion.

Reliability Measures

The two most basic measurements of reliability are as follows:

- Buffer Index: The additional time (margin) required for most trips to ensure on-time arrival. For instance, if the value is 40%, a traveller should allocate an extra 8 minutes as a buffer for a 20-minute average peak trip time to guarantee 95% on-time arrival.

- Planning Time Index: This indicator, known statistically as the 95th percentile Travel Time Index, also shows the additional time most travellers spend for trips during the peak travel period. For instance, a value of 1.60 shows that for 95% on-time arrival, travellers need an extra 60% of travel time over off-peak travel hours.

The above-mentioned measures can be studied or determined by different methods described in the following section.

6. METHODS ADOPTED TO COLLECT THE DATA ON CONGESTION

Author Name	Objective	Data Collected	Methods to collect data	Analysis/Discussion
G. Palubinskas, et al. (2010)	1. To propose a model based on traffic congestion detection. 2. To derive traffic parameters like average speed and vehicle density.	Images from the video	3K Camera system	The suggested method for detecting traffic congestion is based on a mix of several techniques, including change detection, image processing, and assimilation of a priori data like traffic model and road network. The Multivariate

				Alteration Detection (MAD) approach is used to implement change detection in two photos with a short time lag, creating a change image that highlights the moving vehicles on the roadways. It is possible to determine the vehicle density in the binarized change image by using image processing techniques.					nts.
K.R. Priyarakshitha (2018)	1. To determine Traffic volume intensity so that number of vehicles crossing during peak hours and non-peak hours could be identified. 2. To find out the speed of the moving vehicles, conduct spot speed study. 3. Conduct Questionnaire survey to gathering information from responde	Volume, speed, Geometry, Human behaviour survey	Volume count method by Videography method, Speed gun or spot speed study, Questionnaire survey	Bikes travel in greater numbers than cars and autos, whereas cars and autos travel in greater numbers than buses. Therefore, if the number of buses increases, so does the dependency of public transportation, which encourages the users to switch to public vehicles. There are suggestions made to create improved infrastructures, roads, and traffic signals.	**Babitha Elizabeth Philip et al. (2019)**	1. To collect average traffic volume data for a working day, a holiday, and a Sunday in order to determine the peak hour factor. 2. To develop a model that can eliminate traffic congestion and lead to a consistent flow of traffic. 3. To determine the road's geometry and traffic parameters like flow rate and lane capacity. 4. To conduct a questionnaire survey of the general public, drivers, and traffic professio	Volume, Human behaviour survey, Road Geometry	Volume count method by Videography method, Questionnaire survey	There was discussion of the general causes, impacts, and solutions for traffic congestion. A straight link model is established as a means of reducing traffic congestion and achieving effective traffic flow. The queue length created in the lane can be calculated with the help of the model. The developed model could help find the best lane maintenance strategies.

	nals in order to analyse the causes, impacts, and solutions for traffic congestion.							calculate the parameter for traffic congestion.
Tsutomu Tsuboi (2020)	To analyse traffic congestion based on: 1. Comparison of daily traffic volume and average vehicle speed is done by traffic flow observation. 2. Assessment of the occupancy parameter, which is used as a general indicator of traffic congestion. 3. Estimation based on "social loss" calculations that are based on the theory of traffic flow.	Traffic density, Traffic volume, Average vehicle speed, Occupancy at each location.	Traffic monitoring cameras	Three distinct studies of traffic congestion using the standard techniques of observing traffic flow, measuring occupancy, and calculating social loss were conducted. These investigations demonstrate that traffic congestion on individual roads is not always explained by the total hourly number of vehicles. The most congested period of the day is the second peak in the number of vehicles in the evening, according to observations made during traffic flow monitoring. The evening time zone was noted as being the busiest by occupancy judgement. Use of the Social Loss computation can be used to	**S. Berrouk et al. (2020)**	1. To develop a fuzzy inference-based model to measure traffic congestion. 2. To determine independent measures to describe traffic conditions. 3. To provide solutions for uncertain problems through fuzzy process.	Traffic volume, Speed	Wavetronix radar sensor	It is suggested to use a fuzzy inference-based method to assess urban traffic congestion. Defining the various congestion states, computing the values of the congestion index, classifying the input parameter values into distinguishing groups, and computing the input parameter values are all processes in the technique. Out of three inputs that are generally used to measure traffic congestion, it generates a composite congestion measure. The adoption of the suggested fuzzy inference method yields a more accurate depiction of the traffic situation since it takes into consideration even the tiniest differences in the input congestion metrics. The suggested approach can be used to

				assess traffic on particular roads, arterials, or the entire highway network.
Md. A. Shah et al. (2020)	1. To develop a mathematical congestion prediction model for heterogeneous traffic. 2. To assign Level of Service. 3. To make some suggestions for reducing traffic and improving the level of stretch service.	Traffic volume, Speed, Time headway	Videography, Manual count, Radar speed meter	A mathematical model is developed. The proposed effort involves modelling at a single traffic intersection and managing congestion using a minor lane bypass in a road network. MATLAB 7.0 software is used for analysis. The work was divided into two phases, the first of which involved conceptually modelling the proposed system using activity theory, and the second of which involved simulating the conceptually modelled system.
Suchetan Mahapatra et al. (2020)	1. To measure traffic congestion. 2. To develop a model by multiple regression analysis.	Segmental delay (person-second), Segmental delay (vehicle-second), Rate of delay, Relative delay rate	Videography, Manual count	For segmental delay, delay rate, and relative delay rate, a regression model was developed. For segmental delay, multiple regression analysis was performed. Relative comparisons of speeds at different portions were

				also analysed. The parts with the most traffic flow and the slowest speeds were those where congestion was present. Section to section variations occurred in segmental delay and relative delay rate.
Tsutomu Tsuboi (2021)	1. To examine the data on traffic flow collected through traffic monitoring. 2. To determine traffic congestion model.	Traffic volume, Traffic density, Average Speed of vehicles, Occupancy at each location.	Traffic monitoring cameras	The shock wave theory is used to define the "forwarding traffic congestion" model and the "stacking traffic congestion" model. Traffic congestion analysis in India was presented using the occupancy parameter and the shock wave parameter from the traffic theory. Both of these metrics provide information about the current state of traffic congestion. These two parameters help describe traffic congestion conditions for analysis of the chaotic Indian traffic congestion.

Hazratullah Paktin et al. (2021)	1. ___ To identify the primary reasons and possible short-, medium-, and long-term solutions to reduce the congestion. 2. To suggest ways to prevent traffic congestion in Kabul and improve traffic flow.			The primary reasons for Kabul's road congestion were discovered. This article also suggests short-term, medium-term, and long-term solutions for reducing the city's level of congestion.
Nawsheen Tarannum Promy et al. (2022)	1. To conduct a study through semi-structured interviews. 2. An observation to identify the requirements for developing an automated traffic management and control system. 3. To propose an automated traffic control system. 4. To test the	Interviewing people, Visiting locations	Questionnaire survey	In light of the stated needs, a prototype automated traffic management system was developed. For managing and controlling traffic, the proposed approach is effective and efficient. The traffic control system is automated using this system, saving time, money, and labour. Using solar power, the suggested system will reduce traffic congestion and enable the general public become more aware of traffic regulations.
	suggested system's efficacy and efficiency in reducing traffic congestion in a laboratory.			

7. METHODOLOGIES USED TO MEASURE AND ANALYSE THE CONGESTION

G. Palubinskas, et al. (2010) For the purpose of identifying traffic congestion, a new model technique for image time series obtained by an airborne optical 3K camera system is provided. It allows us to develop traffic parameterts that includes both the average speed, one of the key traffic characteristics, and the vehicle density. Parameters like the start and end of congestion, how long it lasted, and travel times. The method relies on prior knowledge, a simple traffic model, and the recognition of vehicles on a road segment through change detection of two images with a short time lag. According to testing results, the proposed technology for identifying traffic congestion on roadways in along-track circumstances has a great deal of potential [12].

K.R. Priyarakshitha (2018) The author concluded that if the majority of people of a particular city starts using the mass transport system, then the roadway congestion can be decreased. This is because the roadway area covered by a mass transport vehicle will be lesser than the area required by private vehicles owned by equal number of passengers. However, mass transportation will only be adopted by the people when its efficiency is high as compared to private vehicles. This efficiency could be money, travel time, safety, and comfort [13].

Babitha Elizabeth Philip et al. (2019) developed a queuing theory-based model for straight lines that helps in the effective movement of traffic flow and significantly reduces traffic congestion. The queue length created in the lane can be calculated with the help of the model. The smooth movement of traffic in the lane will be affected by the propagation of the queue back across the network when the flow in the lane exceeds the lane capacity. The survey data was used to create final samples, which were then examined to determine whether or not they were congested. There was discussion of the general causes, impacts, and remedies for traffic congestion [14].

Tsutomu Tsuboi (2020) determines the three techniques for analysing traffic congestion by o ne traffic flow measure for indicating traffic congestion is occupancy, which is

observed from daily traffic flow by comparing daily vehicle counts with hourly average speeds. (OC) is defined by an equation derived from traffic flow theory. The third technique involves making judgments based on social loss calculations, and, in accordance with the traffic flow theory, the social losses carried on by traffic congestion have defined the traffic road service market model [15].

S. Berrouk et al. (2020) It is suggested to use a fuzzy inference-based method to assess urban traffic congestion. The recommended fuzzy approach is used to calculate the levels of congestion using traffic data, including vehicle numbers, speed, etc. Uncertain problems can be solved using this technique. Three distinct measurements, the speed ratio, volume to capacity ratio, and decreasing speed ratio, each employ unique criteria to represent a certain aspect of the traffic situation. The suggested fuzzy inference method takes into consideration even the smallest variations in the input congestion measurements, and when combined with other methods, it creates a more precise picture of the traffic situation. Since it is based on natural-language principles that precisely reflect how drivers perceive the traffic situation, such a model has a higher level of accuracy. The suggested approach can be used to assess traffic on individual roads, arterials, or the entire highway network [16].

Md. A. Shah et al. (2020) It is important to find a solution for heterogeneous traffic on poor roadway of developing countries like India. A mathematical model is developed. The proposed effort involves modelling at a single traffic intersection and managing congestion using a minor lane bypass in a road network. The work was divided into two phases, the first of which involved conceptually modelling the proposed system using activity theory, and the second of which involved simulating the conceptually modelled system using MATLAB 7.0. It has been established that the results are both competitive and satisfactory [17].

Suchetan Mahapatra (2020) For the purpose of measuring traffic congestion at various crossings, a model was created that takes into account segmental delay (vehicle-second), segmental delay (person-second), delay rate, and relative delay rate. Utilizing the videography method of data extraction, the variables needed for the analysis were created. Free-flowing speed and congested speed were noted down based on a time calculation over a specified stretch. Multiple regression analysis was carried out for segmental delay (vehicle-second) and segmental delay (person-second). For delay rate and relative delay rate, a regression model was developed. In order to determine which area is most and least affected by congestion, relative comparisons of speeds at different portions were also analysed. The parts with the most traffic flow and the slowest speeds were those where congestion was present. Section to section variations occurred in segmental delay and relative delay rate [18].

Tsutomu Tsuboi (2021) uses shock wave theory to develop the "forwarding traffic congestion" and "stacking traffic congestion" models of traffic congestion. In this study, traffic data is collected every minute, around-the-clock, using traffic monitoring cameras. The equation is created using the critical traffic density (k_c) and jam traffic density (k_j) from the theory of traffic flow, and the shock wave is transmitted in both the forward and backward directions. When the shock wave value is zero, either there is no congestion and the traffic is moving smoothly, or there is complete gridlock and no movement. As a result, the definitions of c>0 condition and c0 condition, respectively, are "forward flowing traffic congestion" and "stacking traffic congestion," respectively. These models can be used to explain why there is traffic congestion and suggest solutions for India [19].

Hazratullah Paktin et al (2021) proposed In order to achieve smooth traffic flow, reduce the number of accidents, and make the facilities pedestrian-friendly, traffic management policies and measures would be helpful. The solutions are produced in two stages, the first being short-term actions and the second being medium- and long-term ones. Intelligent transportation systems and high-quality public transportation must be taken into account in plans for the medium and long terms [7].

Nawsheen Tarannum Promy et al. (2022) presented an automated traffic control system. Semi-structured interviews and a number of questions on the issues that cause severe traffic in the city were used in a study to identify requirements. The interview's goal was explained to the participants, who were then questioned about the issues that cause extreme traffic in the city. By visiting several sites, the requirements were determined based on answers. A mobile application for the suggested parking system and a hardware prototype were developed as two parts of the proposed automated traffic control and management system. The traffic control process is automated using this system, saving time, money, and labour. The proposed system, which makes use of solar energy, will help increase public awareness of traffic regulations and ease congestion at a busy city's 4-way intersection [20].

8. SOLUTIONS TO REDUCE THE CONGESTION

A case study of Indore city presented few practical solutions to solve the problem of congestion such as widening of roadway, provision of one-way policy and provision of new alternative road section. Widening of roadway increases the overall capacity of multilane highway, thereby, providing the opportunity of quick movement vehicles per unit of time.

In a study, authors provided the solutions as Improvements to bottleneck intersections, signalization intersections and their management, parking improvements, mid-block U-turning and right-turning points, the issuance of driving

licences to only professional drivers, the strict enforcement of traffic regulations, the need to inform all drivers in various ways to take the rules and regulations seriously, the construction of stops and stations for vehicles and buses, the assignment of stations in specific locations, the signalization of intersections, the management of these improvements, the signalization of bottleneck intersections [7].

The Delhi government introduced the odd-even plan, a traffic restriction measure that allows private cars with odd registration numbers to drive on odd days and cars with even registration numbers to drive on even days. This action was taken to increase public transportation, including more buses and more frequent metro service, in order to prohibit cars, ease traffic congestion, and reduce vehicle-related pollution.

In another study, authors provided the solution of reduced congestion by preventing the heavy commercial vehicles. The elimination of heavy commercial vehicles resulted in smooth traffic movement because of more space is available for other lightweight vehicles. This policy is quite effective, however, it cannot be applied for commercial areas and for city buses.

The use of Traffic Management System (TMS) techniques is primarily used as a short- and medium-term solution to increase the effectiveness and safety of traffic on existing roads. TMS also helps to maximise the use of existing facilities without having a negative impact on the environment. These methods are economical. Traffic management involve bringing changes in the elements of geometric design, roads widening, provision of control devices, and imposing restrictions on some movement in some particular locations.

WORLDWIDE SOLUTIONS

Interventions to Reduce Traffic Congestion-

- Optimise traffic-light management
- Use CCTV to monitor road conditions
- Enforce existing road traffic laws
- Charge for workplace parking
- Improve cycling infrastructure
- Light rail
- Improve perceptions of buses
- Improve bus services
- Existing rail network
- Develop and refine park-and-ride
- Extend residents' parking zones
- Use Inbound Flow Control

- Rationalize distribution and deliveries
- Strategic Road Network resilience
- Road pricing[21]

The One-hit Solution-

- Widen roads
- Narrow roads
- Add bus lanes
- Build tunnels
- Remove bus lanes
- Make buses free
- Build a new ring road
- Build a light rail network
- Ban cycling
- Switch off traffic lights
- Ban cars from city centres
- Build more car parks
- Close through-routes to private vehicles
- Close car parks
- Make park-and-ride free
- Build more park-and-rides
- Introduce a congestion charge/road pricing[21]

The above solutions were given by Smarter Cambridge Transport Authority.

9. CONCLUSIONS

Traffic congestion is a serious social issue which needs special attention. The above literature conclude the following-

- The major factor responsible for traffic congestion is the increase in the number of private vehicle ownership per km road stretch or per million population.

- Due to lack of connectivity and facilities for public vehicle user people use their own vehicles which leads to increase in traffic congestion and by that accidents also increasing day by day.

- The main causes of congestion such as illegal parking, encroachment of main carriageway, insufficient pedestrian facilities, heterogeneous traffic on the same carriageway, poor traffic management, poor traffic control, etc. The solutions for congestion problem are discussed which can reduce congestion by adopting following measures such as widening of road, improvements to

bottleneck intersections, proper traffic management and following traffic regulations, public awareness, parking and pedestrian facilities, maintenance of road etc.

- Government officials from all around the world proposed adding bus lanes, expanding parking lots, subsidising buses, enacting a congestion fee or other road pricing, prohibiting private vehicles from using through roads, etc. as solutions.

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