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Development of Road Congestion Index Based on Comprehensive Parameters

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Abstract*: *Traffic congestion is a normal phenomenon associated with transportation on the road at the same time which is hinder motion and need extra time to reach destinations. Congestion is one of the problems involving road. Normally, network congestion occurs on land transport on roads. As demand approaches the capacity of a road or of the intersection along the road, extreme traffic congestion will sets in. When vehicles are fully stopped for periods of time, this is colloquially known as a traffic jam or snarl-up. Traffic congestion can lead to drivers becoming frustrated and engaging in road rage. In this study of developing congestion index for heterogeneous traffic at the road stretch from Navalur to Kelambakkam and Kelambakkam to Navalur, the study initially focuses on the identification of factors affecting traffic congestion, and finding the most vulnerable location for congestion by developing a congestion index based on speed and saturation degree, with these two important approach solution of each area is suggested. To calculate the traffic congestion index, a thorough literature review has been conducted and all the possible parameters are identified. A questionnaire was prepared with relevant factors affection congestion and distributed to the people, who are resident or frequent users. The most significant factors are considered for further study to avoid congestion. Lack of number of lanes, no pedestrian pathway, on road parking, location of toll were found to be the most affecting factors, so we suggest widening of roads, effective parking system , etc. It is also observed that particular area of Padur and Kelambakkam were the main concern of traffic congestion. This is confirmed both practically and theoretically with the help of the survey and the congestion index values.

Keywords: Traffic congestion, road, congestion index, saturation degree, Pareto chart.

I. INTRODUCTION

A. Road Congestion Index

The measure of vehicle travel density on major roadways in urban area is called road congestion index.

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If RCI exceeds 1.0 it indicates an unacceptable congestion level, on an average, on the freeways and major arterial street during peak hours. The detection and analysis on traffic congestion index can be used to estimate the operation status of roads, to plan and organize road traffic for traffic management, and to make the reasonable decisions of travelers to travel.

Congestion is the inability to move (immobility). Congestion is a phenomenon in which long lines of vehicles moving slowly or stopped at the highway city, suburban highways or city streets. Congestion can occur every day at the same time at a specific location that is referred to as recurrent congestion or accidents during road maintenance or availability of any non-recurring congestion.

Normally, congestion occurs when the road system cannot accommodate the volume of traffic at a reasonable speed, there is a conflict between the various types of traffic such as cars, trucks, buses or pedestrians and traffic control are not used efficiently.

Convergence path, decreasing the capacity of a sudden, that movement is stuck or increased friction also led to increased traffic congestion.

B. Need for study

Traffic congestion during peak hours is a daily problem in the particular road stretch we have chosen for study in this case. Since there are many high rise apartments, educational institutions, IT companies and ongoing new constructions on the road stretch, there is an unavoidable congestion during the peak hours especially during morning hours and evening hours.

Traffic congestion causes interruption to the flow of traffic and instantly affects the society in many ways. We have made an attempt in this study to bring out solutions for this societal problem. The road stretch from Navalur to Kelambakkam which is approximately around 8 kilometer which is located along Old Mahabalipuram Road is considered for our study.

- Navalur is a rapidly growing south suburban of Chennai and the area was once a village (around 2010) but with the advent of IT companies and the rapid development of the Old Mahabalipuram Road, it has become a bustling and most demanded location in Chennai.
- Padur, the rapidly developing part of OMR also positioned between Navalur and Kelambakkam. Padur was known for its commercial growth but, now it is entering into its prime with increasing job openings and residential development into the urban living as well.
- Kelambakkam is a suburban and residential neighborhood. It is located in the south- eastern portion of the city along the OMR and is about 5 km from Siruseri IT Park. It is another important junction after Sholinganalur, which connects GST road and ECR road

II. METHODOLOGY

The first step involves conducting the video graphic traffic volume survey. The data collection was carried out on Monday and Friday at three locations – Navalur near toll gate (L1), Kelambakkam near junction (L2) and Padur near Bus stop (L3). The data is collected for both the directions of road classified as – towards North (R1), towards South as (R2), for two timings – Morning (8-10) as (T1) and Evening (5-7) as (T2).

The table below shows the traffic volume data for Monday and Friday:

Table 1. Traffic Volume Data

Node, Road, Timing	Peak Hour Volume (PCU) Monday	Peak Hour Volume (PCU) Friday
111	2561	2531
211	1670	1771
311	2010	1894
121	4259	4225
221	2212	2321
321	1828	2411
112	2421	3821
212	1446	1568
312	1576	1724
122	1990	2361
222	1855	1899
322	2063	2301

A questionnaire survey has been prepared with relevant factors affecting congestion and conducted the survey.The questionnaire was prepared and the views of the road stretch were collected from the road users and analyzed for finding out the significant factors. Some of the relevant factors considered and the data collected are given in the table below

Table 2. Questionnaire Survey Data

CAUSES OF TRAFFIC CONGESTION	**POINTS**
DELAY DUE TO TRAFFIC VOLUME	89
LACK OF NUMBER OF LANES	94
ON ROAD PARKING	96
IMPROPER SIGNAL TIME PLAN	25
LOCATION OF TOLL	91
BAD ROAD CONDITION	89
NOT FOLLOWING TRAFFIC RULES	39
NEW DEVELOPMENT PROJECTS	21
CLOSURE TIME OF SCHOOL, OFFICE,COLLEGE	22
DUE TO RESIDENTIAL APARTMENTS	20
RECREATIONAL FACILITIES	11
LACK OF PEDESTRIAN PATHWAYS	98
HEAVY MOTOR VEHICLE MOVEMENT	90
PRIVATE GOODS TRANSPORT VEHICLE	28
PRIVATE PUBLIC TRANSPORT	93
ACCIDENTS	41
MISSING SIGN BOARDS	15

From the analysis of questionnaire survey, a pareto chart is created.Pareto analysis is a statistical technique in decision in decision making used for the selection of a limited number of tasks that produce significant overall effect. It uses the Pareto Principal (also known as the 80/20 rule) the idea that by doing 20% of the work you can generate 80% of the benefit of doing the entire job.

Table 3. Pareto Analysis

Causes of traffic congestion	Points	Cumm.	Cumm.%
Lack of pedestrian pathways	98	98	9.29
On road parking	96	194	19.4
Lack of no. of lanes	94	288	28.8
Private public transport	93	381	38
Location of toll	91	472	47.1
Heavy motor vehicle	90	562	56.1
Delay due to traffic volume	89	740	73.9
Bad road condition	89	740	73.9
Accidents	41	781	78
Festival and seasonal factors	40	821	82
Not following traffic rules	39	860	85.9

Private goods transport vehicle	28	888	88.7
Improper signal timing	25	913	91.1
Closure time of school, office & colleges	22	935	93.3
New development of projects	21	956	95.4
Due to residential apartments	20	976	97.4
Missing sign boards	15	991	99
Recreational facilities	11	1002	100

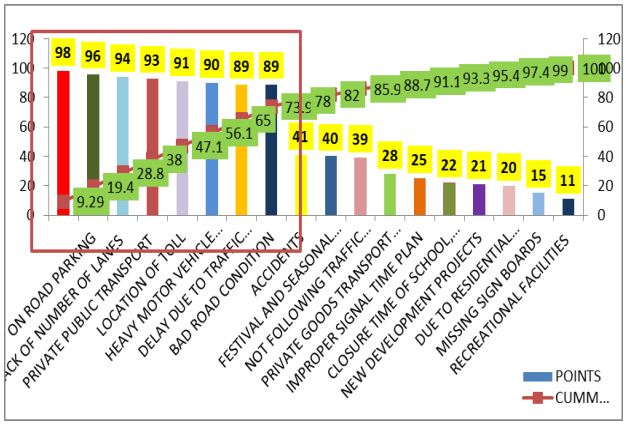

Fig 4. Pareto Chart

III. CALCULATION OF CONGESTION INDEX

A. Congestion Index Based On Speed

Actual speed of the road has to be found out in order to find congestion index based on speed. The distance travelled by the vehicle is noted and the time taken is found out then Actual speed is found out for the road stretch using the formula

Speed = Distance /Time in Kmph

The Congestion Index is calculated using a collected data with the following formula:

$$\mathbf{CI_{LRT} = (V_{LRT} - V^{r}_{LRT})/ V_{LRT} \times 100}$$

CI = Congestion Index; L = Location; R = Road; T = Timing;
V_{LRT} - Acceptable speed (based on IRC);
V^{r}_{LRT} - Actual speed; If $V_{LRT} < V^{r}_{LRT}$ congestion Index = 0 Free flow

Table 4. Congestion index based on speed

Node, Road, Timing	Congestion Index (Monday)	Congestion Index (Friday)
111	34.90%	40.40%
211	48%	42.40%
311	52.90%	47.11%
121	78.60%	83.20%
221	79.10%	81.30%
321	73.70%	73.70%
112	39.10%	39.70%
212	42.66%	46.40%
312	41.33%	54.30%
122	48.50%	42.30%
222	48%	48.60%
322	44.40%	52%

B. Congestion Index Based On Saturation Degree

The designed capacity is 1450 veh/h for one lane (as per IRC) with design speed 45kmph. The extent of congestion will increase when saturation degree enlarge. Saturation degree can be divided into six stages and road congestion index can be calculated in the range of 2–10. (1)

Saturation Degree, x =Volume/Capacity

To calculate the Congestion Index, we have to find the value of saturation degree(x) with the help of traffic volume data from Table1 and the value of capacity as per IRC. With the saturation degree obtained we can calculate the congestion index using the formula below

CI_{LRT} = $x \div 0.4 \times 2$, $x < 0.4$
$(x-0.4) \div 0.2 \times 2 + 2$, $0.4 < x < 0.6$
$(x-0.6) \div 0.15 \times 2 + 4$, $0.6 < x < 0.75$
$(x-0.75) \div 0.15 \times 2 + 6$, $0.75 < x < 0.9$
$(x-0.9) \div 0.2 \times 2 + 8$, $0.9 < x < 1$ 10, $x > 1$

Table 5. Congestion index based on saturation degree

Node, Road, Timing	Congestion Index (Monday)	Congestion Index (Friday)
111	27%	27%
211	38%	41.30%
311	50%	46%
121	65.30%	65.30%
221	66%	66.70%
321	64%	70.60%
112	25%	32%
212	30%	34%
312	34%	39%
122	18.50%	24%
222	45.30%	45%
322	45.30%	65.30%

IV. DISCUSSION AND SOLUTIONS

From the above congestion index based on speed and saturation degree, 6 most congested location, road and timing is found out from each cases. From there we can see 4 repeated significant congestion level **in Navalur** road 2 from 8-10 am, **8** in **Padur** road 1 and 2 from **8-10 am**, 3 in **Padur** road 2 from 5-7pm, 1 in **Padur** road 1 from 5-7pm **4** in **Kelambakkam** road 2 from **8-10am**, 1 in **Kelambakkam** road 1 from 8-10am, **4** in **Kelambakkam** road 1 from 5-7 pm, 1 in **Kelambakkam** road 1 from 5-7pm.

SOLUTIONS:

From the survey and Pareto chart the most significant factors are found, the solution of each factor is studied with the help of various research papers and each way for avoiding the causes of traffic congestion is suggested as follows:

- **LACK OF PEDETRIANS PATHWAY**

Existing road width of Padur is 5.73m on both sides with 1.74m for both parking and walkways but sometimes this is also being blocked by roadside vendors or it is being occupied by the road users during heavy traffic and also a carriage way of 4.2m.

Fig 2. Pedestrian packed on the carriageway

Widening of 1.5m width shoulders on both sides for 1.2km is necessary to ease traffic congestion as this particular stretch is the most strained location in the study area. Pedestrian footpath for at least 1.5m is suggested as per IRC Guidelines, pedestrian road width are shown for commercial and residential zones in the figure below along with this restriction of street vending in certain congested area.

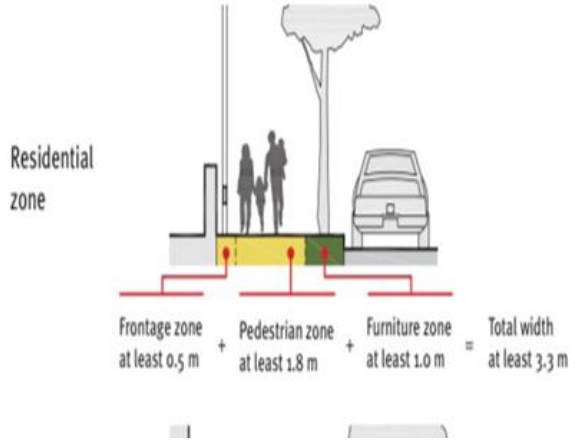

Fig.3 Pedestrian pathway for residential zone

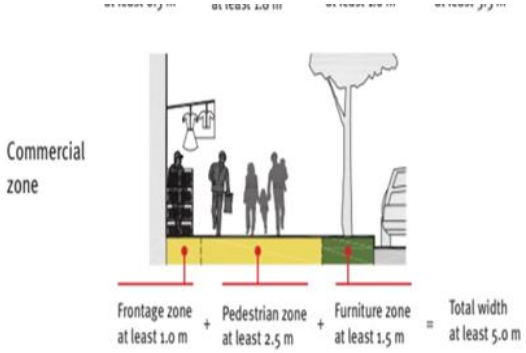

Fig.4 Pedestrian pathway for commercial zone

- **ON STREET PARKING**

Properly planned and managed on street parking is necessary for smooth flow of traffic, proper lane markings, allocation of parking space. Parallel parking is suggested as they offer much less disruption to the moving traffic but parking and un-parking might be challenging. The figure below shows different types of parking along with the parking width where parallel parking occupies a road width of 2m.

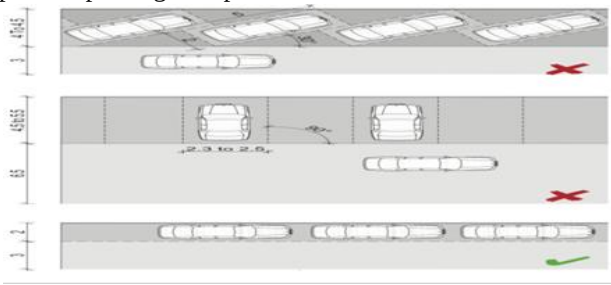

Fig.5 Types of parking

- **LACK OF NO. OF LANES**

Lack of no. of lanes can be seen in two particular location of the study area i.e. Padur and Kelambakkam whereas the lanes in the Navalur area is wide enough but the road users violating the road rules is the major factor of traffic congestion. Widening is another solution suggested which will allocate vehicle parking and pedestrian footpath, thereby, allocating sufficient road width and no disruption in the carriage way. Widening need not be implemented for the whole study area of 8 km, for an economical approach we can implement it in the Padur locality for about 1.2km where most of the street vendors, bus stops and Hindustan Institute of Technology and Science is located and another 1.5 km at Kelambakkam located between two main junctions i.e. Kelambakkam-Vandalur junction and Kelambakkam-ECR junction.

Fig 6. Existing Road width (red) and widened area (green)

The below figure shows the aerial view of Padur and the no. of U-turns allowed in a distance of 1.2Km, the road width in Padur area is 4.2m on each direction with a shoulder width of 1.5m and in some particular area the roads are even narrower due to encroachment by the street vendor.

There is a U-turn at Hindustan university and there are 4 U-turn roads at about 350m, 160m, 140m, 60m, 210m respectively due to this behavior the roads are frequently blocked, the location of bus stop and u turn area overlapped which leads to increase in the road congestion during peak hours.

Fig 7. Flow of traffic at Padur

- **PRIVATE-PUBLIC TRANSPORT**

Due to the specific locations of many IT companies, there is a high demand for public private transport in this stretch. More than thousands private public transport uses the road being a major concern for the road congestion causes. Some of the examples of private-public transport are auto, mini-van, mini-bus, etc.

Specific stops – As like state owned public transport if specifics can be assigned for private transport to avoid sudden stops which is the cause of many minor accidents.

Continuous flow of such traffic should be encouraged, awareness sign boards can be installed to keep the road users well informed, strict rules should be imposed to stop the violation of traffic rules.

- **LOCATION OF TOLL**

The tollgate on the Rajiv Gandhi Salai is a dreaded task; it takes a minimum of 30 minutes to cross the tollgate during rush hour. Because of this, many motorists take the wrong side of the road to avoid waiting.

Fig 8. Traffic congestion due to collection of toll

Electric toll collections can be installed, it is a wireless system to automatically collect the toll fee, it is a faster alternative which is replacing toll booths where vehicles must stop and the driver manually pays the toll with cash or a card. In most systems vehicles are equipped with an automated radio transponder device. A major advantage is that it can help reduce traffic congestion and any traffic delay. Other solutions include separate lane for each category of vehicle so a homogenous flow can be maintained to avoid unwanted delays. Another factor to be considered is the location of unnecessary turns near the toll booth which is always a major problem triggering to congestion; the left turn to access the local roads can be blocked during peak hours to avoid congestion.

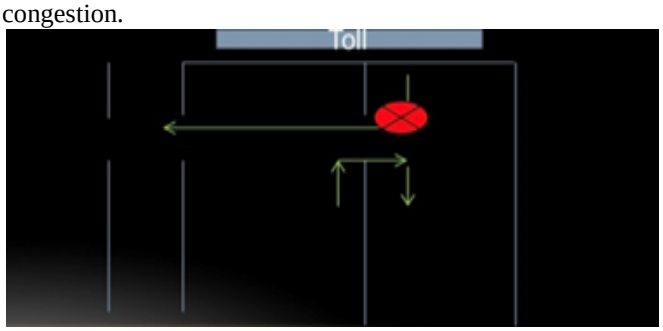

Fig 9. Left turn not allowed

V. CONCLUSION

In the study the attempt has been made to determine the congestion index at different places in a stretch of road from Navalur to Kelambakkam and from Kelambakkam to Navalur. The combination of the two approaches - questionnaire survey and congestion Index is very effective. Based on the questionnaire survey the most vulnerable points of traffic congestion were identified. The congestion index for these identified places were determined based on the speed of the traffic and saturation degree Padur is found to be the most congested area during peak hours.

REFERENCES

1. Huimin Wen, Jianping Sun, and Xi Zhang. "Study on Traffic Congestion Patterns of Large City in China Taking Beijing as an Example", Beijing Transportation Research Center. The 9th International Conference on Traffic & Transportation Studies (ICTTS'2014)
2. Wanxiang Wang, Rui-jun Guo and Jing Yu, School of Transportation Engineering, Dalian Jiaotong University, Dalian. "Research on road traffic congestion index based on comprehensive parameters: Taking Dalian city as an example". Issue published: June 1, 2018
3. Amudapuram Mohan Rao and Kalaga Ramachandra Rao, "Measuring Urban Traffic Congestion – A Review", Indian Institute of Technology Delhi, Department of Civil Engineering, Hauz Khas, New Delhi; International Journal for Traffic and Transport Engineering, 2012.
4. Zhao, Pengjun and Hu, Haoyu. (2019). Geographical patterns of traffic congestion in growing megacities: Big data analytics from Beijing.
5. Shekhar K. Rahane and Prof. U. R. Saharkar, "Traffic Congestion - Causes and Solutions: A Study of Talegoan - Dabhade City". Journal of Information, Knowledge and Research in Civil Engineering. ISSN: 0975 – 6744| NOV 13 TO OCT 14 | Volume 3, Issue 1.
6. Syed Sabreen and Paramjeet, Civil Engineering Department, Geeta Engineering College, Naultha, Panipat. "Analysis of Traffic Congestion in Srinagar City - A Review". September 2018 IJSDR | Volume 3, Issue 9.

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