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Study on Intervening Effects of Influencing Factors on Traffic Congestion in an Urban Road Network

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Urban Traffic Congestion is being considered as a major problem in transportation engineering and will certainly become the bottleneck in further development of nation's economy, if it continues to worsen. Road network in the urban areas constitutes one of the essential infrastructures for the development of the city and also to meet the demands of the people. In the current scenario of the traffic in many parts of the world the road users are facing problems of mobility, accessibility and connectivity within a road network. With the rise in population and advancement of technology, an increase in the travel demand has been observed and subsequently the facilities pertaining to transportation have also increased. As the cities are growing at a rapid rate with reference to Business, Commercial, Educational and technological aspects, the land use pattern is also getting promoted to decentralized activities of business, educational and residential. Due to this the functionality of the road is changing but then the geometrical condition remains same which leads to many urban traffic issues. In short the traffic has become dynamic but the network characteristics remains static. The travel time has gone up to 1.4 to 1.5 times the journey time due to congestions resulting into a burden or loss to society of about 1.44 Lakh crore as per a uber study in recent times. This paper presents a study where an existing urban road network is delineated from the existing city and captured using Google Earth and Qgis using digitization technique. Subsequently the road Networks is studied in detail with respect to the different influencing factors which are found to be actually leading to traffic congestions.

Keywords: Urban Traffic Congestion, Landuse, Supportive Infrastructure, Stationed Vehicles.

1. Introduction

Road Transport plays a vital role in the social and economic development of any country. Transportation is very essential for the economic development of any region since every commodity which is produced and every service that is rendered produces warrants for transport at production & distribution stages, the inadequacy of which retails the socio-economic development of the country. Thus transportation occupies a high place in modern life. Urbanization provides the necessary infrastructure for trade, commerce and industry.

Urbanization attracts the surplus labour force from the rural areas and utilizes it in the running the various service which are vital to the existence of town. In advanced countries and at abroad, the level or urbanization is rather high. Utilization of land by different activities is promoting complex interactions, which are non-uniform in a time frame over a specified space occupation. The citizens are facing the problems of overcrowding which is the result of high intensity of the residential land uses which is reflected in the density of houses, households, populations etc.

In most of the Indian cities people try to live as close to the city centre which is modified by other factor such as accessibility and different social economic status and so forth.

Cities and traffic have developed hand-in-hand since the earliest large human settlements. The same forces that draw inhabitants to congregate in large urban areas also lead to sometimes intolerable levels of traffic congestion on urban streets and thoroughfares. Effective urban governance requires a careful balancing between the benefits of agglomeration and the dis-benefits of excessive congestion. Road traffic congestion poses a challenge for all large and growing urban areas. Congestion prevents us from moving freely and it slows and otherwise disrupts the conduct of business within urban areas. However, it is important to note that unfettered movement is not the primary benefit we derive from living in urban areas. Cities provide access to a wide range of activities, people, services, goods, markets, opportunities, ideas and networks. These benefits can be delivered either through speed or through greater proximity.

Traffic congestion also influences accessibility and mobility. Traffic congestion increases travel time and fuel costs, which adversely effecting organizations and employees distributing goods and services. Traffic congestion is normally described as the traffic demand surpassing the roadway capacity. Traffic density (the number of vehicles in a specified length of a roadway) is one of the most frequently used congestion indicators. The travel time reliability measures such as level of service, roadway congestion index and lane-mile duration index can also be considered to identify the traffic congestion parameters. For evaluating the traffic congestion in the urban roadway, the speed performance index is one of the indicators. There is extensive mental as well as physical stress on drivers because of traffic congestion and increases their aggression which might induce unfortunate incidents like road crashes. Every day by millions of people across the globe are directly affected by the traffic congestion. This research aims to analyze the traffic congestion impacts of the urban road network of a smart city in India. Congestion indices have been evaluated to examine the operational efficiency of the road network. In order to plan the trips productively and to choose the routes suitable travel time reliability measure has a significant part to the travelers. Finally, the study also examines the traffic congestion impacts and its mitigation measures.

2. Literature Review

Chen, Z., Zan, et al [1] This study used SD-NDGM to establish an urban congestion mitigation and emission-reduction management model. Based on dynamic simulation analyses of the effects of traffic policies from a medium- and long-term perspective, the following conclusions

can be presented. Jan Lizbetin, et al [2] In their study to deals with the formation of congestion particularly on urban roads, where the driver reaction time influences the size of congestion as well. In the first part of the paper the issues of traffic flow and congestion formation are theoretically discussed. Verma, A., Harsha, V [3] This study finds that most government policy initiatives are still to see the intended level of success. This is majorly due to lack of monitoring, complex institutional capacities and urban governance, irregular zoning of land and inefficient comprehensive development and mobility plans.Vilayath, Mirza, [4] visualized the fractal view of different urban areas and suggested to analyze the road network on different parameters Accessibility, Mobility, Connectivity, Self –Similarity (Visualizing the fractal view) to improve the existing infrastructures. Behavior and characteristics of links were studied and subsequently Transverse Corridors and Longitudinal Corridors with the feeder roads to increase the functionality of the sub-arterial roads were proposed. Boeing [5] stated that research in multiple literature streams has considered cities, ecosystems, and other Physical phenomena in terms of systemic complexity. Chen and Huang [6] demonstrated an experimental method to find parametric models for the growth curves of fractal dimension of Chinese urban form. By statistical analysis, numerical analysis, and comparative analysis, it was observed that the quadratic Boltzmann equation and quadratic logistic function can be used to characterize the fractal dimension of the urban land-use pattern of Beijing city which increases in the course of time. Salingaros [7] developed an edge in a geographical sense, and applied geometrical analysis to the general morphology of coastal cities. The coast was considered as a fractal line, with very special mathematical properties and presented a method of analysis which can be applied to design new urban growth and to repair existing urban fabric that has been damaged by any interventions.Zhang, Sen, Shaobo Li et al [8] In this work, in order to reduce the usage of computational resources while at the same achieve optimal performance, we first propose a framework to represent urban road traffic network congestion levels. This was used to utilize historical records of traffic congestion data with a large size to predict future short-term traffic congestion levels.X. Lokesh K Shobhan Majumder [9] The study employed an analysis of travel time through the study stretch. This study is to evaluate congestion of urban sub arterial road in terms of travel time indices during peak hours of a working day and non-working day. To do this, various existing travel time reliability indices are considered and are examined. Chepuri et al.[10], examined travel time under mixed traffic conditions on urban arterial roads in Indian cities. The study carried out for examining travel time reliability under heterogeneous traffic conditions on three different urban arterial road sections in the cities of Ahmedabad and Surat in India. Karuppanagounder and Muneera [11], carried out travel time-based performance evaluation of urban links under heterogeneous traffic condition. Travel time based indices comprising delay, planning time index, congestion index and travel time index were used to evaluate the performance of the urban link.

3. Methodology

In the present study the study area is captured through digitization technique from Google Earth and using Qgis the study area is demonstrated with larger accuracy. The study area so formed is studied in details with respect different influencing factors – Traffic Composition, Stationed Vehicles, Violation of Right of Way, Road Geometrics, supportive infrastructure, Network Access and Network Connectivity. The study has shown that much of the attention

was given to traditional factors in the past but the current scenario of the congestion in urban networks has changed due to its influencing factors apart from the fractal / non-fractal view of network.

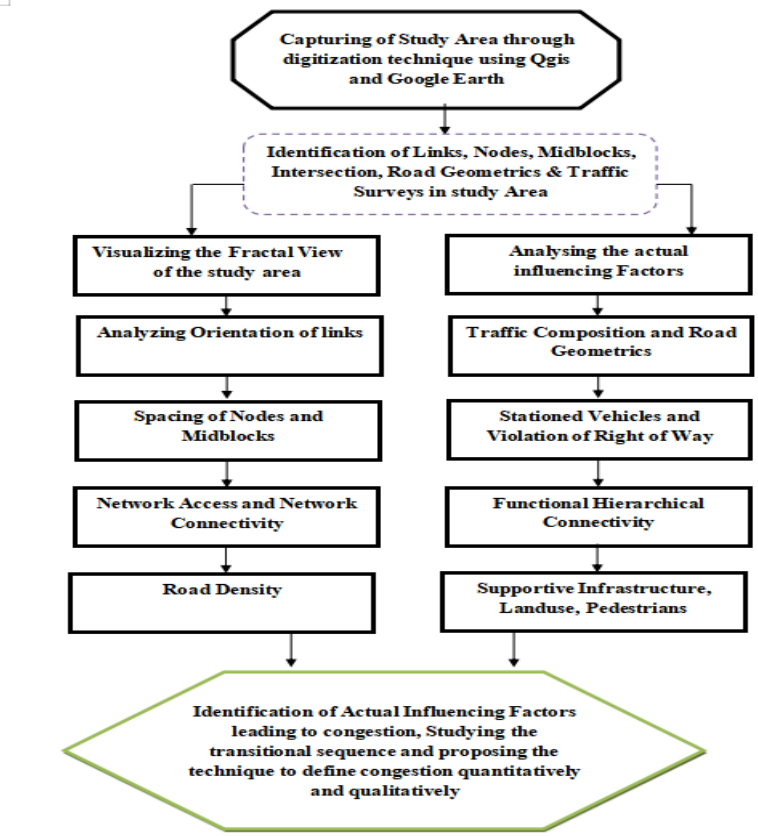

Figure 1: Proposed structure of research methodology

Data Collection and Data Processing:

Hyderabad is the capital and largest city of the southern Indian state of Telangana located at 17.3667° N, 78.4667° E. It occupies 650 square kilometers (250 sq mi) on the banks of the Musi River. Its population is 6.8 million, and its metropolitan area increases that number to 7.75 million people, making it India's fourth most populous city and sixth most populous urban agglomeration.

Three National Highways pass through the city:NH-7, NH-9 and NH-202. Five state highways, SH-1, SH-2, SH-4, SH-5 and SH-6, either begin at or pass through Hyderabad. As of 2010, maximum speed limits within the city are 50 km/h (31 mph) for two-wheelers and cars, 35 km/h (22 mph) for auto rickshaws and 40 km/h (25 mph) for light commercial vehicles and buses.

Study Area – 1 Ameerpet

- An area of radius 1.25 Km from the Ameerpet Junction constitutes the study area.

- It includes many commercial business districts, Education Institutes and Residential Colonies apart from the recreational centres and many Govt Offices like HUDA, BSNL, Electricity office etc in its vicinity.
- Many traffic generation and attraction centres exist in the area like Govt offices. Apart from this the arterial roads feeds the thorough traffic from Khairtabad, Errum Manzil, Punjagutta, Ameerpet, S.R Nagar, ESI and Kukatpally via public and private transport systems.
- Arterial and Sub-Arterial Roads in the study area are Non-Functional because junctions are located at shorter intervals resulting into the formation of many mid-blocks. Absence of feeder road at many places is leading the arterial & sub-arterial roads non-functional.

Study Area – 2 Nizampet

- An area of radius 1.25 Km from the Nizampet Junction constitutes the study area.
- Many traffic generation and attraction centres exist in the area like JNTU, Shopping centres etc. Apart from this through traffic flow on the Nizampet X Roads converging from Ram Naresh Colony, Brindhavan Colony, Vasantha Nagar, Aditya Nagar, Pragathi Nagar, Tulasi Nagar towards Hitec City Roads exist in the study area.
- The type of traffic in the study area is mixed type which includes public as well as private transport systems.
- Arterial and Sub-Arterial Roads in the study area are Non-Functional because junctions are located at shorter intervals resulting into the formation of many mid-blocks. Absence of feeder road at many places is leading the arterial & sub-arterial roads non-functional.

Fractal analysis:

Fractal analysis in the context of road geometrics and traffic involves examining the complexity and patterns of road networks and traffic flows. By using fractal analysis, one can study how road networks develop, how traffic distributes itself, and even predict potential congestion points based on the geometric patterns of the roads.

Table 1 – Fractal Analysis of Ameerpet Study Area 1 for link orientation weightage

Fractal Analysis of Ameerpet			
Sl.No	Direction	Counts	Percentage
1	N	38	2.90
2	S	34	2.60
3	E	42	3.21
4	W	79	6.04
5	NE	275	21.01
6	NW	386	29.49
7	SE	154	11.76
8	SW	301	22.99

Table 2 – Fractal Analysis of Nizampet Study Area 2 for link orientation weightage

Fractal Analysis of Nizampet			
Sl.No	Direction	Counts	Percentage
1	NE	201	22.95
2	NW	147	17.55

3	SE	233	28.12
4	SW	252	31.38

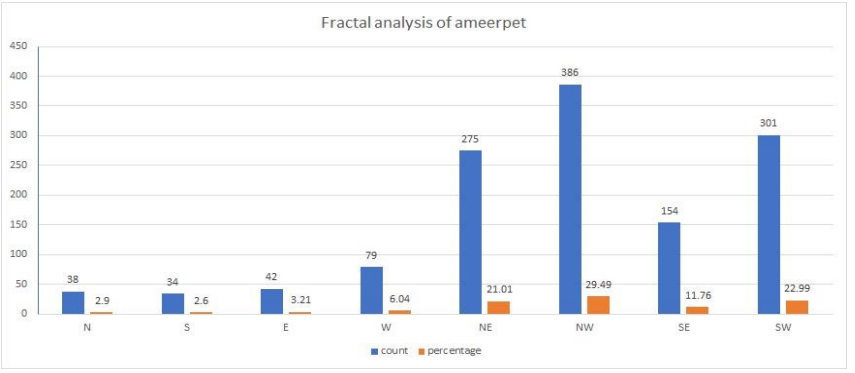

Figure 2 – Road Network Similarity view of Ameerpet

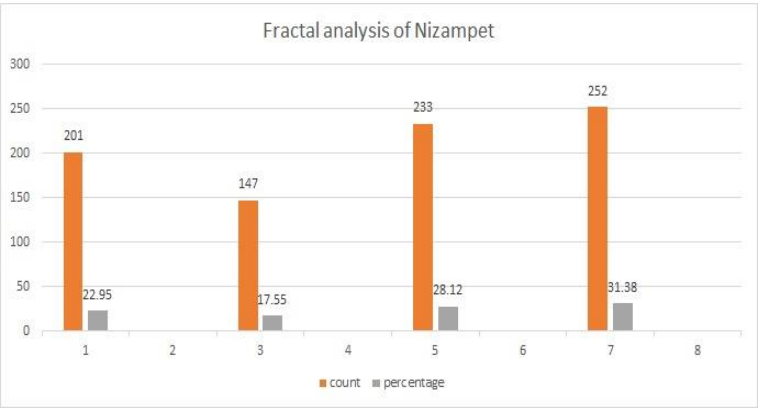

Figure 3: Road Network Similarity view of Nizampet

Table 3: Analysis of Road Geometric and Land Use in the study areas

Link Name - Krishna Nagar "T" Junction to Srinagar Colony "T" Junction.				
S.No	Section of Road (kM)	Geometrics	Land Use	Remarks
1	0.2	Width of Road = 7.0 M Shoulder = Available Right of way = Not Available Footpath = Available Collector Streets = 0 Mid blocks = 0	Auto Stand Commercial Shops.	
2	0.12	Width of Road = 7.0 M Shoulder = Available Right of way = Not Available Footpath = Available Collector Streets = 2 Nos Mid blocks = 0	School	Extra width of Road.
3	3.53	Width of Road = 7.0 M Shoulder = Not Available Right of way = Not Available Footpath = Available	Banks and other Commercial Shops	For some portions of Road Footpath is not available

		Collector Streets = 14 Midblocks = 3		
Link Name - Maitrivanam "T" Junction to Yousufguda "T" Junction.				
		Width of Road = 7.0 M Shoulder = Not Available Right of way = Not Available Footpath = Not Availabale		
4	0.3	Collector Streets = 0 Midblocks = 0 Width of Road = 7.0 M Shoulder = Available Right of way = Not Available Footpath = Available	Commercial Shops Sri Chaitanya School, Value Mart Market, Petrol Pumps, Residential Appartments	Metro Rail is available
5	0.8	Collector Streets = 9 Midblocks = 0 Width of Road = 7.0 M Shoulder = Not Available Right of way = Not Available Footpath = Not Available		Occupancy by Road side vendors
6	0.14	Collector Streets = 0 Midblocks = 0 Width of Road = 7.0 M Shoulder = Available Right of way = Not Available Footpath = Not Available	Residential Appartments, Commercial business centres	At a point in the link "Y" is available.
7	0.06	Collector Streets = 0 Midblocks = 0	Commercial establishments	Link is heading towards densely populated residential zone
Link Name - S.R. Nagar Junction to Balkampet "T" Junction.				
		Width of Road = 7.0 M Shoulder = Not Available Right of way = Not Available Footpath = Not Availabale		
8	0.7	Collector Streets = 9 Midblocks = 1 Width of Road = 21 M Shoulder = Available Right of way = Not Available Footpath = Available	Commercial Hotels, Banks.	Signalized Junction is available at Midblock.
9	0.3	Collector Streets = 3 Midblocks = 1 Width of Road = 7.0 M Shoulder = Available Right of way = Not Available Footpath = Available	Residential and Commercial.	width is available extra when compared to other portion of link
10	0.55	Collector Streets = 4 Midblocks = 4 Width of Road = 7.0 M Shoulder = Available Right of way = Not Available Footpath = Available	Residential and Commercial.	Signalized Junction is available at Midblock.
11	0.25	Collector Streets = 2 Nos Midblocks = 0	Schools, Petrol Pumps, Residential Appartments	Holy places available.
Link Name - Greenland Junction to Elephant House Junction near Ameerpet				
12	0.3	Width of Road = 21 M Shoulder = Available	Commercial establishments, Dr.	No Shoulders and footpath

		Right of way = Not Available Footpath = Not Availabale Collector Streets = 1 Midblocks = 0 Width of Road = 7.0 M Shoulder = Not Available	Reddy Research Labs	
13	0.27	Right of way = Not Available Footpath = Not Availabale Collector Streets = 0 Midblocks = 0 Width of Road = 7.0 M Shoulder = Not Available	Commercial establishments.	Signalized Junction is available at Midblock and Metro Rail Project is in Progress.
14	0.33	Right of way = Not Available Footpath = Not Availabale Collector Streets = 2 Nos Midblocks = 0	Commercial establishments.	Metro Rail

Figure 4 – Proposed Transverse Corridors in the study areas 1 (Ameerpet)

Ameerpet is a bustling commercial and residential area in Hyderabad, known for its dense road network and heavy traffic, especially due to the presence of educational institutions, shopping centers, and business hubs. Transverse corridors in Ameerpet refer to the roads or pathways that intersect the primary thoroughfares, contributing to the area's overall connectivity and traffic dynamics.

Transverse Corridors: Identify the streets that cross these main roads. Some of these might include roads like Balkampet Road, Dharam Karam Road, and various smaller lanes that facilitate lateral movement within Ameerpet.

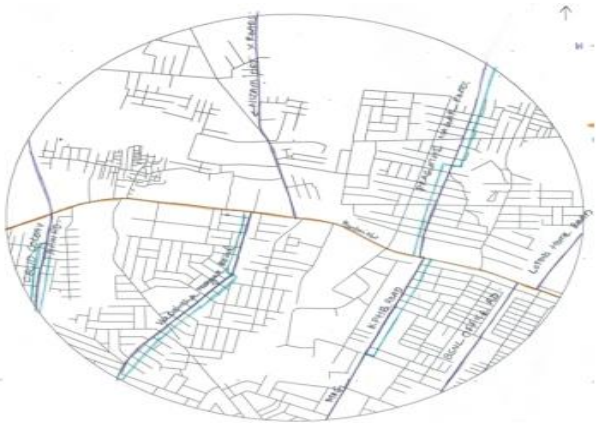

Figure 5 – Proposed Transverse Corridors in the study areas 2 (Nizampet)

This approach will give you a comprehensive understanding of the role and impact of transverse corridors in Nizampet, helping in effective planning and management of the area's transportation network Transverse corridors refer to the cross-sectional or lateral paths that intersect or traverse the main routes or networks within a specific area. In the context of Nizampet, which is a growing suburban area in Hyderabad, India, transverse corridors would typically include roads, streets, or pathways that connect various parts of the area

Transverse Corridors: Use QGIS tools to highlight the transverse corridors. You can create separate layers for these corridors for easy visualization. To Identify the roads that cross these main roads include local streets and connectors that link different neighborhoods within Nizampet.

Conclusion

- The Land Use patterns in the Study Areas comprises of Commercial Zones, Residential Zones, Industrial Zones and other recreational Centres apart from many Public buildings which serves as main attraction centers attracting traffic from many parts of the city. The landuse is very dynamic in the study area but the supportive infrastructure and road geometrics are unchanged over a time which is leading to congestions.

- Orientation of the links in different direction are as given in Table 2 which illustrates that the orientation in a particular direction is uniform and Fractal but, if it is considered on overall basis the network is Non – Fractal.

- The functionality of the existing network is poor due to the presence of many junctions at irregular intervals which has resulted the sub-arterial and arterial roads non functional. Feeder roads can be provided to enhance the functionality of the road network in the study areas.

- The actual influencing factors which are leading to the traffic congestions are Network Deficiency, Geographical deficiency; Traffic Composition. Also there is more number of collector streets directly connected to the arterial roads leading to congestions.

- Congestions are also highly influenced by the factors – Absence of Shoulders and Right of Way. These are predominant in many areas where parking facilities are not available and the road users are using the carriage way width for their short commitments which is leading to ques in the study areas.

- Improper functional hierarchies of roads are resulting into serious congestion spots wherein sub-arterial roads are working to the tune of collector streets. Absence of feeder roads at adequate intervals is resulting into concentration of traffic congestions at localized level and leading to long delays.

- Proposal of transverse corridors will not only reduce the nodes where a collector street meets a sub-arterial way but also promotes smooth movement resulting in reduction of ques and delays. The main idea behind the proposal of transverse corridors is to avoid the intrusion of vehicular traffic directly to the Sub-Arterial Roads from number of points.

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