International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 12, Issue 5 [May. 2023] PP: 351-356

Functional Analysis and Modelling Of Urban Mobility Network

Manish Kumar[1], Miss Shivani[2]
mks90.iimt@gmail.com
[1]*M.Tech. Student of Transportation Engineering, Department of Civil Engineering, Sat Priya Group of Institution Rohtak, Haryana-127028*
[2]*Assistant Professor in Department of Civil Engineering, Sat Priya Group of Institution Rohtak, Haryana-127028*

Abstract *:- Urban mobility efficiency requires a simultaneous interaction of urban structure and transportation systems. Urban activities define urban development. Traffic is a result of the interaction between the urban activity system that generates the mobility demand, and the transportation networks supply. Continuous population growth in cities, urban sprawl and time lag regarding the equilibrium supply-demand may create excessive traffic congestion and, thus, inefficiency. The international trend recuperating public space for citizens (tactical city planning) and the trigger of Covid19 pandemics puts pressure on the "right" supply and layout of transportation networks of a city. This research focuses on how to adapt infrastructure and land uses to meet the mobility needs in a city. We seek a balanced design among transportation networks, population distribution, land use, and infrastructure. A macroscopic approach identifies the infrastructure requirements to reach an appropriate level of service for urban mobility.*

A Continuous Approximation formulation for a concentric city includes the key performance conditions of public and private transportation infrastructure. The analytical models use variables defined as densities, and solve the optimization problem minimizing the total costs. We apply the four-step Urban Transportation Planning process as defined in the Transportation Study: trip generation and attraction, spatial distribution, modal split and traffic assignment using the incremental method. We focus on the role of heterogeneously distributed demand, design effects on urban structure based on functionality, and we test several policies. Multi-center cities can reduce the total costs between 2.6% and 11.6%, which is relevant as a planning measure. Autonomous vehicles could have a neutral effect on the reduction in travel costs. When we apply the models, the system optimization advises to increment the subway services and lines.

Date of Submission: 09-05-2023 Date of acceptance: 20-05-2023

I. INTRODUCTION

A city is a portion of a region where the population is concentrated and where there are businesses, services, and sometimes-even industries. A city's residents do not have to go from one place to another for a long time because it is not a static system. Work, education, and other objectives. Additionally, people must transport goods between two locations due to the manufacturing-related needs of a city. Consequently, a city is a complex system made up of elements that are dispersed unevenly over its area, both residential and non-residential.

In this sense, the operation of both urban mobility and transportation impacts the urban space used by cars, transit, logistics vehicles, and other modes (motorized, no motorized, and active mobility). Historical, social, and geographical conditions define the physical characteristics of a city. The physical layout of a city may come from planning, natural development for a long time, or a mixed process of both. For adequate functional planning of a city, planners should consider both the transportation system operation and infrastructure to enhance people's mobility and freight. People buy more automobiles as the economy grows. As a result, new vehicle owners will stop using public transportation and instead drive. Transit operators may raise prices, cut back on service frequency, or do both. As a result, the transit is even less appealing than before. The city will eventually see rising traffic, transit vehicle delays, an increase in operational expenses, and additional transit user charges. Finally yet importantly, the traffic system will be more appealing, and more people will favour purchasing new automobiles. Regarding the growth in traffic, the number of private automobiles depends on the rise in income, but also on other variables, such as the cost of cars, insurance, parking, the accessibility of garages, and the degree of annoyance brought on by traffic, alternate less expensive forms of transportation, and modifications to travel routines or behaviours. The number of freight trucks will expand, but it will rely on how useful this form of transportation is for businesses. This result can only be avoided by putting management or planning policies in place that promote public transportation while simultaneously discouraging the use of private vehicles. Cities must also handle transportation and traffic while reducing system costs and protecting the environment.

1.2 Transportation problems

Congestion is a condition reached when a new vehicle enters into the traffic flow, increasing the travel time for other vehicles (Bull & Thomson, 2002). Congestion costs can increase more rapidly than traffic growth. Congestion, delays in trips, and other causes may frustrate commuters. However, two situations may partially cause those frustrations: the increase in the number of vehicles and the design, structure, and capacity offered by cities. The congestion may affect the main characteristic offered by cars: the ability to provide a door-to-door service. It may deteriorate citizens' work performance who use a car, even more for people who use it as a work tool. This externality can even affect the economic efficiency of a country. Regarding the increase in traffic, the number of private vehicles depends on the increase in salaries, but also this increase depends on other factors, for

example, the price of cars, insurance, parking, garage availability, level of frustration due to traffic, other cheaper modes of transportation, and changes in travel habits or patterns. Regarding freight vehicles, the increase in vehicles will depend on the utility of this transportation mode for companies. The excessive growth of cars generates a decline in the transit of the spiral type. This process is known as the "vicious circle of public transportation" (see, for example, Ortúzar & Willumsen, 2011)

According to the vicious circle (Figure 1.1), economic growth encourages people to buy more cars. Therefore, new car owners will leave the transit system and use their cars. Transit operators will increase fares, reduce frequencies (level of service), or both. The transit is thereby less attractive yet than before. After a few years, the city will face increasing congestion, delays in transit vehicles, an increment in operating costs, and new fares for transit users. Finally, the traffic system will be more attractive, and other people will prefer buying new cars.

1.3 Quality

In a decision-making process of transit services, a potential user will consider at least one or a combination of the following attributes of a public transportation system: reliability, waiting time, security concerning walking, waiting, and riding, trip comfortability, trip cost, number of transfers, and travel time considering all stages of a trip.

The design of transit networks should consider the above operating factors. It is worth mentioning that decisions in the urban planning process usually do not consider those factors. Some factors are more accessible to incorporate into urban planning than others. This research includes most of those factors but not considers specific operating variables, i.e., security and comfortability. The "quality of service reflects the passenger's perception of transit performance" (TCQSM, TRB, 2013). Two factors classify the qualityof transit services: transit availability and transit comfort and convenience. The former determines whether a transit system is a feasible option for a trip; the latter measures passengers' comfort and convenience for a transit system. Transit comfort and convenience only have relevance whether a transit service is available.

1.4 Consequences on urban systems

Cities have been spreading out for decades. In transportation, several reasons support this assertion, e.g., cars provide freedom of movement in a city. A road network is a connex graph—there is at least one path between two points—in which a rational driver will choose the shortest path (minimum travel time in a congested system). That freedom and the increase of speed have boosted that drivers increase the traveled distance during their travels, e.g., longer commuting. The extensive use of automobiles affects the urban form, causing urban sprawl (urban dispersion), among other consequences. Figure 1.2 shows the vicious circle of consequences that generate congestion in a city. Congestion generates impacts on the environment and, at the same time, people's pressures to increase road capacity. Thus, cities invest in infrastructure to reduce travel times, e.g., the construction of freeways. The new capacity often generates a reduction of friction to mobility, and new users change their modal choice to private transportation. This new scenario and other components promote urban sprawl in cities. Drivers also have some limitations; one of them is parking. Due to the scarcity of urban land, parking in central areas is more expensive than in the periphery. This factor only thereby comes to justify that cities had spread out in the last decades. The answer is neither clear nor unequivocal between concentrated urban areas (high density) and scattered (low density). The dispersion can quickly become sprawl whether automobiles are the center of mobility in a city. New urbanizations—new cities or extensions of existing areas—must adopt new forms based on transit services. The infrastructure could adapt it, or it could maintain a balance between both components. The increment in population, the number of cars, and the urban sprawl cause congestion. This consequence has limited the benefits of investments made for the reduction of travel times.

1.5 Management and planning

some strategies allow solving conflicts between transportation and urban problems, i.e., TSM/TDM strategies.

1.Transportation systems management (TSM): Strategies of relatively low cost developed during the '70s for improving a transportation system. TSM actions can influence supply and demand for encouraging the efficiency, safety, capacity, or LOS of a transportation system without increasing the infrastructure size or other expensive large-scale actions (Schoon, 1996). Some strategies aim for traffic signal improvements, intersection improvements, intelligent transportation systems, and others.

2.Transportation demand management (TDM): Strategies that increase the productivity and efficiency of a transportation system, modifying demand behavior (Ferguson, 2018). TDM strategies encourage the increment of car occupancy, modal change to transit, and reducing congestion, e.g., moving car trips outside of rush hour, carpooling, non-motorized travel, parking management, financial incentives, and others. Both types of strategies have implementations in the short or medium term. In both previous cases, the objective of these strategies is to optimize the use of existing infrastructure, these even require certain minimum infrastructure conditions, so there will be positive effects on transportation

1.6 Spatial planning instruments

The development of spatial planning instruments (SPI) materializes urban planning in cities. These instruments are norms, plans, or even strategies that encourage positive transformation actions on a territory. The actions work over public and private entities, and these have a medium-to-long-term goal. The Chilean regulations identify three types of instruments: normative, indicative, and exceptional protection zones, e.g., urban development plan, urban regulatory plan, the master plan of transportation, and others (Precht, Reyes, & Salamanca, 2016).

II. LITERATURE REVIEW

1. Rodrigue et al. (2017)- the writers has identified that an urban form is defined by a transportation system's physical infrastructures and the spatial impression they leave behind. An urban spatial structure is defined by the links between the urban form and the exchanges between people, goods, and information. This allows researchers to assess how an urban structure may alter or adapt to a particular transportation system, and vice versa.

2. Wegener and Fürst (2004) notes in their paper of state of the art about landuse and transportation interaction (LUTI). After that, Acheampong and Silva (2015) provide an overview of some 60 years of research in the field of LUTI modeling. The authors emphasize that this type of modeling has challenges for its improvement. New technologies—e.g., GIS, microsimulation, and others— have enhanced this research field, although models must understand the uncertainty propagation over time.

3. Chen et al. (2015) propose an analysis of urban networks using two continuous approximations (CA) models, which minimize a cost function. The first case analyzes a city with a ring-radial structure, and the second case considers a grid structure for a transit system.

4. Smith (2014) evaluates the impact of spatially heterogeneous demand over a hybrid transit system considering a transit network design with elastic demand.

5. Li et al. (2013) proposed a system equilibrium model to optimize a primary road network density. The model applied to a two-dimensional monocentric city considers four agent types: local authorities, housing agencies, households, and workers. The optimization model determines the density of main roads maximizing the social welfare of the system.

6. Ibarra-Rojas et al. (2015) describe a list of transportation problems considering their scale, i.e., strategic, tactical, and operational planning decisions. According to strategic decisions in network design, discrete and continuous methods can solve transportation problems, although this assertion extends the analysis to any strategic planning decision.

7. Miyagawa (2018) proposed an analytical model to determine the optimal spacing between roads considering a hierarchical grid road network with two types of roads: minor and major roads. The travel time has two components: free travel time and the delay at road intersections. Moreover, the model is useful for designing hierarchical road networks. This model optimizes the average travel time and analyzes trade-offs between the travel time on types of roads. According to its results, several variables affect the optimal road pattern, e.g., the road length, the intersection delay, the travel speed, and the city size. Moreover, the model analyzes the effects on the accessibility to primary roads and intersections. Finally, the author applied the model to Tokyo city

8. The article writes by Tsekeris and Geroliminis (2013) uses the "macroscopic fundamental diagram" (MFD) to analyze the relation between traffic and land use applied to a concentric city.

9. Vaughan's paper (1986) analyzes the behavior of a ring-radial network considering a many-to-many demand. A continuous function represents the commuting trip demand. The buses travel at a constant speed, and the model imposes a fleet-size constraint.

10. Daganzo (2010) analyzes characteristics of shape and operation in order to provide a high level of competitiveness for a public transportation network. The author models a square region with a uniform density, which combines a grid with a hub-and-spoke pattern.
11. Badia et al. (2014) present an extension of the hybrid model formulated by Daganzo (2010). The modeling considers a ring-radial pattern in the central area and hub-and-spoke in the periphery. The model minimizes a cost function with four decision variables: CBD size, headway, the spacing between routes, and stops. In this line, other works are possible to mention, e.g., Foletta et al. (2010), Estrada et al. (2011), and Roca-Riu (2012). Chen et al. (2015) propose an analysis of urban networks using two continuous approximations (CA) models, which minimize a cost function. The first case analyzes a city with a ring-radial structure, and the second case considers a grid structure for a transit system.
12. Dupuy (2008) points out that the analysis of the city-mobility approach should consider three dimensions: - Topological dimension: This dimension encourages urban opening and decentralization, e.g., a ubiquitous network ensures the maximum connection in a city independent of location, barriers, or limits. - Kinetic dimension: This considers the speed of movements in a network.
- Adaptive dimension: The ability to adapt networks to needs demanded. This dimension ensures the permanence and long duration of the infrastructures
13. The first cities did not have any planning or, in some cases, a few rules defined a minimal layout in ancient cities, which had an orientation to walking mainly. Therefore, cities were compact with activities agglomerated in mixed uses. Many modern cities inherited this morphology in which walking and cycling join a high percentage of the modal partition, e.g., European cities and Eastern Asian cities. Australian, Canadian, and American cities have encouraged the use of private transportation. On the other hand, Latin American cities were their origins defining a grid center, but those grew expansively without strengthened planning.
14. (Rodrigue et al.,2017) Transportation and its evolution have generated changes in the shape of cities. Technological changes in public and private transportation have allowed users to move away from historical city centers. In terms of infrastructure, agencies began to build radial and ring/circular roads, which promoted the development of suburbs. Simultaneously, new clusters that group activities defined a polycentric structure; thus, commuters did not only travel to the CBD. Also, distribution centers appeared in the suburbs to generate new connections for a city, a region, and the world (Rodrigue et al., 2017). Transportation modes in a city simultaneously define the urban and
Network shape. Snellen et al. (2002)

OBJECTIVE

1. To design best model for transportation in city
2. To minimize the problem of traffic in the city
3. To improve the traffic condition of the city
4. To analysis focuses on urban density and sub centre regarding urban structure

III. PROPOSED RESEARCH

3.1 PROBLEM DEFINITION

A standard question emerges for old or new cities, for concentrated or dispersed cities, or any other type of city: “How is it possible to adapt the infrastructure and all land uses— residential and non-residential—to meet the needs of people who want to travel for any purpose and mode” The previous question promotes a balanced network design between the distribution of population and land uses and its infrastructure. This new interdisciplinary approach focuses its theory on articulating urban space through the concept of network, i.e., networks generate their spatial organization, and these continually evolve. This new approach has a direct connection between urbanism and network operability. The transportation system and the urban system must have a connected operation because both depend on the other. Thus, a planner should take a similar role as a network operator to solve an urban problem correctly. Therefore, traffic and transit are an essential part of an urban planning problem. The above means that spatial components in transportation components are essential, and urban planning requires planning instruments for its implementation over a region. The planning instruments can be normative, indicative, or investment portfolios. The elaboration of these instruments needs studies to define the quantity and type of infrastructure for a town. Since these plans are long-term, the design of the infrastructure network is a crucial factor. Hence, these new methodologies allow contributing to engineering and urban planning. Urban planning must consider that a city needs minimum physical conditions to be satisfied in order to maintain an adequate level of urban mobility and transportation by considering heterogeneous demand.

Conditions include, e.g., urban size, location, and size of the central business district (CBD), the proportion of public space destined for transportation relative to the built space, the spatial distribution of land uses, and population density, among others. If a city does not meet these minimum physical conditions, the transportation supply must adapt to the demand or vice versa. Thus, TSM and TDM strategies could guarantee an adequate level of urban mobility. However, all TSM and TDM management strategies also require minimal infrastructure conditions for their success. Policies and strategies may be favorable and improve urban mobility as long as the network design and infrastructure supply enable it. In this way, in the design and infrastructure supply, the decision variables of a transportation problem can simultaneously restrict a transportation system's ability to achieve efficiency in urban mobility

3.2 METHODOLOGY

Urban planning must consider that a city needs minimum physical conditions to be satisfied in order to maintain an adequate level of urban mobility and transportation by considering heterogeneous demand. Conditions include, e.g., urban size, location, and size of the central business district (CBD), the proportion of public space destined for transportation relative to the built space, the spatial distribution of land uses, and population density, among others. If a city does not meet these minimum physical conditions, the transportation supply must adapt to the demand or vice versa. Thus, traffic service management (TSM) and traffic demand management(TDM) strategies could guarantee an adequate level of urban mobility. However, all TSM and TDM management strategies also require minimal infrastructure conditions for their success. Spatial planning instruments require several studies to determine the infrastructure needs considering the demand of a city. This research aims to develop a macroscopic method to identify the infrastructure needs that sustain an adequate level of service for urban mobility and transportation. The proposed methodology based its formulation on analytical models to deduce the critical components of a network structure. These key components must ensure the critical conditions of the private and public transportation infrastructure.

3.3 Future Scope

My main focus will be to determine optimal characteristics for an adequate design of urban networks considering the urban form and structure. The methodology focuses on a concentric city considering the functionality in designing a primary transportation network regarding urban form. The analysis focuses on urban density, transportation systems, a central business district, and sub centers regarding urban structure.

3.4. Result & Conclusion

Urban locations provide enormous difficulties. One of the first is the requirement to pack them full of people. Second, in already crowded cities, population and activity continue to grow quickly. The earlier problems as well as the urban sprawl is an inorganic dispersion that is mostly influenced by autos. Urban planners are continually torn between designing dense or dispersed cities. The benefits of the internet and other contemporary communications may make it unnecessary for traditional concentrated cities to exist today. Given the foregoing, it would seem acceptable to promote urban sprawl, yet land scarcity is a current problem that necessitates a balanced relationship between the countryside and cities. My research hypothesis exposes a question promoting a paradigm change in traditional urban planning: the need for a balance between the infrastructure and residential and non-residential densities to optimize the mobility for any purpose and mode

REFERENCES

[1]. Nili, M. Biglarijoo, N. Mirbagheri, S.A. A Review on the Use of Various Kinds of Debris and Demolitions in Concrete and Mortar Mixes. 10th International Congress on Advances in Civil Engineering. 17-19 October 2012 Middle East Technical University, Ankara, Turkey.

[2]. Sai Samanth, A, Prakhar. Study of Strength Properties of Concrete with Construction Debris as Aggregates. International Journal of Engineering Research in Mechanical and Civil Engineering. 1(5), 2016, pp 42-45.

[3]. Kumar, N.S.T. Siva, C. Use of Construction Renovation and Demolition Waste in Partial Replacement of Coarse Aggregate in M20 Concrete. International Journal of Research in Engineering and Technology. 4(10), 2015, pp 375-378.

[4]. Muthu Lakshmi, S. Nivedhitha, R.R. Efffect of Partial Replacement of Aggregates by Recycled Concrete Debris on Strength of Concrete. Malaysian Journal of Civil Engineering. 27(2), 2015, pp 250-259.

[5]. IS 456 (2000): PLAIN AND REINFORCED CONCRETE - CODE OF PRACTICE.

[6]. IS 383 (2016): SPECIFICATION FOR COARSE AND FINE AGGREGATES FROM NATURAL SOURCES FOR CONCRETE.

[7]. IS 2386-3 (1963): METHODS OF TEST FOR AGGREGATES FOR CONCRETE, PART3: SPECIFIC GRAVITY, DENSITY, VOIDS, ABSORPTION AND BULKING.

[8]. IS 10262 (2009): GUIDELINES FOR CONCRETE MIX DESIGN PROPORTIONING.

[9]. IS 516 (1959): METHOD OF TESTS FOR STRENGTH OF CONCRETE.

[10]. IS 7320-1974.., specification for concrete slump test apparatus.

[11]. I.S: 2386-1963, Methods of Test for aggregates for concrete - Part 3: Specific gravity, Density, Voids, Absorption and Bulking, Bureau of Indian Standard, New Delhi.

[12]. I.S: 1199-1959, Indian Standard Methods of Sampling and analysis of concrete. Bureau ofIndan Standards, New Delhi.

[13]. Ramzitaha et al. (2011), 'Effect of Copper Slag as a Fine Aggregate On the Properties of Cement Motars and Concrete', Construction and Building Materials, pp. 25933–938.

[14]. Specification for 53 grade ordinary Portland cement (IS:12269-1989)

[15]. M.Iqbal Malik, Muzafar Bashir, Sajad Ahmad, Tabish Tariq, Umar Chowdhary " Study of concrete involving use of Waste Glass as partial replacement of fine aggregates" Vol.3, Issue 7, July. 2013, IOSR Journal Of Engineering IOSRJEN

[16]. Dr.Haider K. Ammash, Muhammed S. Muhammed, Ali H. Nahhab, "Using of waste glass as fine aggregate in concrete" Vol 2, 2009, Al-Qadisiya Journal For Engineering Sciences.
[17]. Dr.G.Vijayakumar, Ms.H.Vishaliny, Dr.D. Govindarajulu "Studies on Glass Powder as partial replacement of Cement in Concrete production" Volume 3, Issue 2, February 2013, International Journal of Emerging Technology and Advanced Engineering.
[18]. M. Adaway(January 2014) Australia: Recycled glass as a partial replacement for coarse aggregate in structural concrete – Effects on compressive strength'' Electronic Journal of Structural Engineering 14(1) 2015
[19]. Y. Wang, "Recycled glass as a partial replacement for fine aggregate in structural concrete – Effects on compressive strength", Electronic Journal of Structural Engineering, Vol. 14, Issue
[20]. Veena V. Bhatt and N. Bhavanishankar Rao, "Influence of Glass Powder on the Properties of Concrete", IJETT, Vol.16, Issue 5, Oct. 2015, pp.196-199, ISS:2231-5381 .p.116- 122, 2015
[21]. C Meyer, N Egosi , C Andela - Concrete with Waste Glass as Aggregate, Recycling and Re-use of Glass Cullet", Dhir, Dyer and Limbachiya, editors,
[22]. Ashutosh Sharma and Ashutosh Sangamnerkar, "Glass Powder-A Partial Replacement for Cement", International Journal Of Core Engineering & Management (IJCEM), Volume 1, Issue 11, February 2015, pp. 86-93, ISSN: 2348