The Model of Arranging Trip Demand to the Central Areas of the Cities by Creating Traffic Restricted Zone

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***Abstract*—Faced with traffic issues, just increasing the capacity and offering more supply could not be the best option. Increase in the supply will result in the increase of demand. Optimum use of network capacity without spending huge costs, only by using management methods and tools is one of the goals of trip demand management to decrease the traffic problems. Applying special traffic restrictions for typical vehicles in some internal urban pathways is an example of these restrictions. The central part of the city has special importance because of the existence of important and trip attractive land uses there. Improvement of traffic and promotion of public transportation usage are among the goals of this management policy. So in this study, a model for creating a traffic restricted zone has been suggested and its effects on the network functional factors are investigated. Then the suggested model is evaluated by simulation through EMME/2 to create a traffic restricted zone typically in Tabriz city. Finally, as a result of this survey, the effects of implementation of this plan to improve the traffic management in central part of the city are studied.**

***Index Terms*—Demand, traffic restricted zone, trip assignment, trip distribution, trip matrix.**

I. Introduction

Applying traffic restrictions in some urban pathways is done with the goal of directing traffic from crowded streets to retired streets (the optimum use of existing capacity) or promoting the use of public transit which is among the public goals of management policies and solutions. But the special goal of traffic restriction policy is the improvement of traffic in strategic and important zones of the city which often include the center of the city. Generally this could be commented that time value isn't the same for all users or transportation systems. The central core of the city has a great importance because of the main and significant land uses there. The density of traffic around mentioned land uses will decrease by defining the boundary of traffic restricted zone and preventing the transit of individual vehicles, and therefore particular vehicles such as public and emergency vehicles could simply access to this area.

Noticing the goal of this plan, the traffic toll should not be determined in a way that results in the fail of the plan. The traffic toll value should not be so high that most of people could not pay it. If this occurs, the plan will not have general acceptance and will lose and if the traffic toll value be low, the effect of the plan will not be obvious.

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II. Preparation of Network Pathways

For traffic modeling, it is essential to be aware of the information of pathways like streets, junctions and their time table, streets width, the kind of function of each pathway according to its standing in the hierarchy of network and information related to the public transportation including lines, stations and navy. This network is implemented in the Arc Map software using the information available in urban traffic management investigation system and according to strategic projects of traffic and field observations and investigation and coincidence of public network with physical network of pathways. Then the pathways defined in the range will be specified by a code[1]

III. Estimation of Trip Demand in Traffic Restricted Zone

The policy of applying traffic limitations is a management policy that is achievable in a short period with a suitable cost. In the definition of traffic restricted zone which is accomplished to reduce the amount of traffic by increasing and developing the use of public transportation vehicles, only two groups of vehicles have permission of transit:

- Public and emergency vehicles
- Vehicles with license

Authorized vehicles are personal vehicles which their owners pay congestion charge to get permission to enter the range to do some necessary work or to be easy in transit. The traffic restricted zone is a specific area that surrounds more attractive usages and due to the applying of traffic restrictions, the amount of traffic is decreased considerably. And since increasing the use of public transportation is one of the main goals of planning and implementing this plan, applying limitations in giving certification and determining suitable price for it, are effective parameters in the performance and function of this policy. Investigation of the function of restricted traffic areas shows that a model could be designed that about 70 percent of people who work and inhabit in this range, get certification of transit and the 30 percent remaining will tend to use public transportation system. In this situation, 80 percent of the people will use bus system and 20 percent of them will use taxi services. The above pattern could be considered as the basis of trip demand estimation process[2].

The whole trip demand presently could be estimated via trips information bank and the matrix of trips distribution between zones. Also trip demand in the perspective of plan could be estimated noticing the annual growth of the trips and considering trip growth coefficient. Having trip information in hand, the matrix of trips that their origin or destination are one of the zones inside the limited area suggested and used individual vehicles, could be derived and named as $mf70$. According to the described pattern, matrix $mf70$ (trips done with individual vehicles and their origin or destination are inside the limited area) is parted as shown in Fig.1:

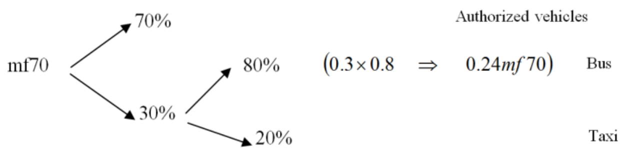

Fig. 1. Trips done with individual vehicles and their origin

For building$mf70$, first matrix $mf41$ (trip demand for individual vehicle) is distributed on the destinations inside the zone so that $mf40$ is achieved. Then this process is accomplished for the origins being at the zone (distribution on origins) to achieve $mf50$ and then $mf60$ is resulted by distributing on origin and destination of the matrix and finally mf70 is computed through the below equation:

$$mf70 = mf40 + mf50 - mf60 \tag{1}$$

After that, trip matrix with bus is grown up to value of $0.24mf70$ that is shown in equation below:

$$mf10 = mf44 + 0.24\, mf70 \tag{2}$$

$$mf44 = mf10 \tag{3}$$

where $mf44$ is matrix of trips done by bus (per person). In the following, it's essential to evaluate this model for long term perspective, since in most of considered cities for this model, until now the subway system hasn't been utilized and by utilizing these systems and the improvement of public transportation system in future, the effects of increasing the ratio of public transportation should be examined. For traffic modeling two public (bus) and nonpublic (personal) matrix is prepared for the future decade by estimating all of trips for the perspective of year 2021 based on pattern observed at year 2011 for the chosen vehicle assuming the growth that will occur by utilizing subway system in the use of public transportation system. Matrix of ratio of public trips to total of:

$$mf99 = \frac{mf44}{mf98}\left(\frac{Public}{Total}\right) \tag{4}$$

$mf98$ Is the matrix of all of trips done now (based on individual).

$$mf90 = \frac{mf22}{Max(mf32,1)} \tag{5}$$

$mf90$ Is the ratio of public trip time in current year ($mf22$) to public trip time ($mf32$) when utilizing subway. Then public matrix in the year of plan perspective ($mf52$) is achieved as below:

$$mf52 = Min(mf90 \times mf49 \times mf99,1) \tag{6}$$

where, mf49 is the total estimation of trips in the year plan implemented.

The non-final matrix of nonpublic trip in the year of perspective is accounted as following:

$$mf51 = mf49 - mf52 \tag{7}$$

for updating the $mf51$ (non-final matrix of trips in year 2021 with nonpublic vehicles) and $mf52$ matrix (non-final matrix of trips in 2021 with public vehicles) and building $mf71$ matrix, we do this way: the $mf70$ matrix as before is built on $mf51$ matrix as a result matrix of origin-destination trips in the year of plan perspective with nonpublic vehicle (personal) which its origin or destination is one of the traffic zones inside the traffic restricted zone is computed:

$$mf70 = mf40 + mf50 - mf60 \tag{8}$$

$$mf40 = \sum\nolimits_{q\in R} mf51 \tag{9}$$

$$mf50 = \sum\nolimits_{q\in R} mf51 \tag{10}$$

$$mf50 = \sum_{p\in R}\sum_{q\in R} mf51 \tag{11}$$

q= destination zone which is a member of R.

p= origin zone which is a member of R.

R= collection of zones inside the traffic restricted zone.

$$mf80 = mf51 - mf70 \tag{12}$$

$$mf10 = mf52 + 0.24\, mf70 \tag{13}$$

$$mf52 = mf10 \tag{14}$$

In above relations, 24 percent of $mf70$ matrix trips is attracted by use of bus ($mf52$). Remaining trips of $mf70$ include trips with authorized vehicles:

$$mf70 \times mf10 = (1 - 0.24) \tag{15}$$

$$mf70 = mf10 \tag{16}$$

The matrix of unauthorized vehicles trips is computed as below:

$$mf51 = mf80 \tag{17}$$

The computed matrixes relate to the year of plan perspective. Finally matrixes of modelling the traffic restricted zone are calculated as below:

$$mf81 = \frac{mf51}{voc} \times \frac{1}{(1+i)^{2021-t}} \times POT \tag{18}$$

$$mf82 = mf52 \times \frac{1}{(1+i)^{2021-t}} \times POT \tag{19}$$

$$mf71 = \frac{mf70}{voc} \times \frac{1}{(1+i)^{2021-t}} \times POT \tag{20}$$

t= assumed year ($2011 \le t \le 2021$)

$mf81$ = the matrix of origin-destination trip with unauthorized vehicle in year t (based on vehicle)

$mf82$= matrix of origin-destination trip by bus in year t (based on individual)

$mf71$= matrix of origin-destination trip with authorized vehicle in year t (based on vehicle)

voc: Vehicle Occupancy Coefficient

POT: Peak Over Total

In this manner, values of triple matrixes pertaining to the current year and the future decade (distribution of trips related to the traffic restricted zone) are calculated for traffic analysis and evaluation.

IV. Traffic Analysis

Traffic analysis is accomplished by modeling of traffic allocation in the environment of EMME/2 through the equilibrium allocation problem solving method (with capacity restriction) based on Frank & Wolf`s Linear approximation algorithm[3]. In this method, it is assumed that every user chooses the shortest path. This assumption leads to a pattern of flow in the network that satisfies the conditions of user equilibrium of wardrop as such after receiving to an equilibrium, no user could choose a shorter path by changing his/her path. Traffic allocation model of EMME/2 with constant request is as the following [4], [5]

$$Min\ f(v) = \sum_{a\in A} \int_0^{v_a} S_a(v + x_a)dv$$

$$v_a = \sum_{k\in K} \delta_{ak} h_k : a \in A \tag{21}$$

$$\sum_{k\in K_{pq}} h_k = \left(\frac{g_{pq}}{\eta_{pq}}\right) + \gamma_{pq} : p \in P, q \in Q$$

$$h_k \geq 0 : k \in K_{pq}, p \in P, q \in Q$$

$S_a(v)$: Function of trip time to volume related to arc a.

$a \in A$: The arcs (streets) of pathways network

$k \in K_{pq}$:The collection of pathways connecting origin p to destination q.

If the arc a is in the path of k, δ_{av} will equals 1.

g_{pq}: Trip demand (based on individual) from p to q.

η_{pq}: Aboard Coefficient (individual per vehicle) from p to q.

γ_{pq}: Extra demand based on vehicle, related to trips with public vehicles.

x_a: Extra volume on arc a, related to trips with public vehicles.

V. Scenario Building

The option of traffic restricted zone is modeled for network and the current year demand and then analyzed for the year of plan perspective. According to that, at first, current situation scenario at 2011 year is built which has not any traffic limitations. And then the scenario of suggested zone is built for analyzing and feasibility study. Also a similar scenario is designed for year 2021. In Table III. the characteristics of each of the scenarios mentioned above are introduced from network and demand point of view [6].

TABLE I: Scenarios Designed for Investigating of the Traffic Restricted Zone.

Scenario	Demand	Network	Public system	Explanation
11111	2011	Network of 2011 without traffic restricted zone	Public	Do nothing scenario
21111	2011	Net work of 2011 + traffic restricted zone	Public	Scenario of making traffic restricted zone
12121	2021	Net work of 2021 without traffic restricted zone	Public + subway	Do nothing scenario
22121	2021	Net work of 2021 + traffic restricted zone	Public + subway	Scenario of making traffic restricted zone

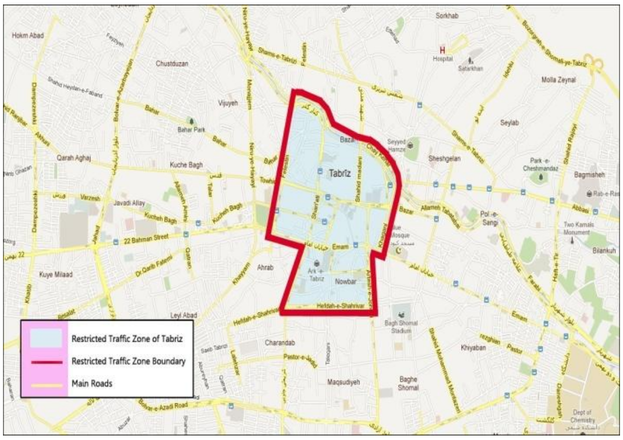

Fig. 2. Suggested traffic restricted zone of Tabriz.

VI. Investigation of Suggested Model for Tabriz City

Tabriz city is typically studied for investigating the offered model to create the traffic restricted zone and determining the effects and results of it on the traffic characteristics of central district of the city. The suggested zone is indicated according to Fig .2

The suggested range for the traffic restricted zone in the case study of Tabriz city starts from Ghari bridge (Pole Ghari) and in the way of northern Khaghani street after passing Daneshsara square it enters southern Khaghani street and continues up to Imam street and in the west direction of this street after passing Sa`at square, it enters southern artesh which in the Bagh Shomal crossroad leads to

Shahid Ghazi Tabatabayi street and in its way passes Shahid Ghazi Tabatabayi crossroad and arrives 17 Shahrivar junction and in the northern path it goes across Shariati street and in the Shariati crossroad toward west it reaches Baghn-e-fajr square and enters Felestin street then go through the former Terminal square and Felestin crossroad and the junction of Bahar - Felestin and arrives Chaykanar and finally in its way to the east it leads to Ghari bridge.

The most traffic in this range belongs to southern Artesh, Shariati and Shahid Ghazi Tabatabayi streets.

To do traffic modeling, collecting the information of crossings network of Tabriz city is required which is very costly and time consuming. This information is prepared in the site of special information of crossings network.

The central district includes a lot of commercial land uses, important medical centers, numerous parking places and streets which are among important routes and also significant places and agencies. To calculate urban trip demand considering the amount of the annual average growth of trip in Tabriz city $i = 2.764753\%$, and the portion of peak hour trips from the whole of the trips $POT = 0.11$ and average of aboard coefficient of personal vehicles $VOC = 2$, the total demand of urban trip in Tabriz city is calculated in current perspective and the plan according to annual growth [7].

$$D_{2011} = 2889702 \qquad D_{2021} = 3933620 \tag{22}$$

Therefore the values related to triple matrixes like the traffic restricted zone of 2011 and 2021 are indicated in Table I.

The required models for traffic modeling in Tabriz city are documented in emme/2 software and traffic analyses will be accomplished on this basis. However the mentioned software has the capability to accomplish mathematical processes on the matrixes. This capability is used to estimate the timely demand and. To do that a special program has been written in Macro language which not only estimates the timely demand and does simultaneous traffic assimilation but also there is a possibility to do sensitivity analysis on the parameters of demand estimating. In the traffic plan issue, all of the personal vehicles are not permitted to use all of the crossings of the transportation network. Accordingly this group of vehicles depended on the definition of the issue will be divided in different classes that every class is permitted to use the crossings defined for that class. For this reason modeling of traffic plan issue pertains to the multimode traffic assignment issues.

Traffic operation in the network is shown after loading the demand in the above scenarios in Fig.3 and Fig.4 Distribution of traffic volume in the network is seen divided as (v/c). Applying traffic limitation reduces the traffic volume considerably in these pathways regarding that it decreases the trip demand in the pathways inside the restricted zone. Also by applying these limitations in the central district, the traffic of these pathways which most of the time is passing will be directed to surrounding pathways out of the zone so the capacity of surrounding pathways is used more.

Also investigation of technical and environmental factors indicates that creating traffic restricted zone causes improvement of these characteristics. If the policy is done, the improvement will be seen in the plan perspective of 2021 in the central area. The values of these indexes and the efficiency of them after applying the range are shown in Table II..

Fig 3. Show of traffic volume in scenario

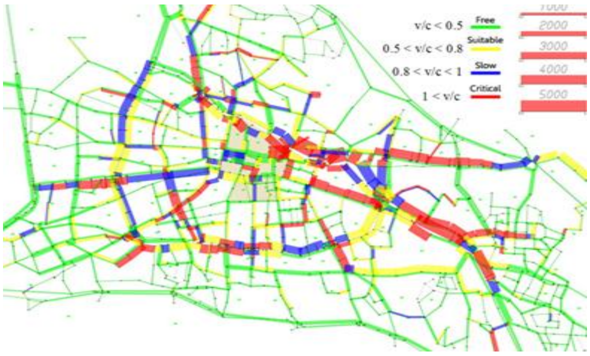

Fig. 4. Show of traffic volume in scenario 21111.

TABLE II: TRIP DISTRIBUTION OF TABRIZ CITY IN PEAK HOUR PERTAINING TO DEMANDS OF 2011 AND 2021.

	2021		**2011**	
	Percent	Trip per individual	Percent	Trip per individual
Unauthorized vehicle trips ($mf81$)	70.43	223834	67.05	290116
Trips by Bus ($mf82$)	29.07	92412	32.45	138463
Authorized vehicle trips ($mf71$)	0.50	1588	0.50	2164
Total	**100**	**317835**	**100**	**430743**

TABLE III: COMPARISON OF THE AMOUNT OF POLLUTANTS PRODUCTION AND THE TRIP TIME INDEX IN 2011 AND 2021 ANALYSIS.

	Scenario 11111	**Scenario 21111**	**Scenario 12121**	**Scenario 22121**
Total pollutant gases	237102.38	197340.31	205361.48	166732.71
Fuel consumption	71307	59826.57	64368.2	52769

Universal index of time (UIT)	785860.1	785860.1	690481	519241.7
Percent of Trip Time decrease	22.3		24.8	
Percent of Fuel consumption decrease	16.10		18.02	
Percent of pollutant gases decrease	16.77		18.81	

VII. Conclusion

Importance of central area in large cities encourages the enthusiasm for traffic management. The problems in central fabric emerge both by the network weakness and supply system and also by the huge demand of trips to the zone. So the control of demand by creating a traffic restricted zone would be a management and important solution. As the primary goal of applying traffic restricted zone, urban planners believe that the value of wasted time due to the delay and traffic is not the same in all parts of the city, obviously by applying the traffic limitations in the central part of the city ,the trip time will increase around the range. However the trip time in the limited area will decrease considerably. To judge about implementation of traffic range policy, we should first determine the worth of time for the policy makers and people involved in urban transportation planning. Also the existent capacities have great attractions for other trips that are not related with the traffic range but their path is in a way that they could use the streets inside the range. This characteristic persuade transportation managers to use the existent potential by adjusting suitable charges and in addition to generating income that justifies the economic aspects of the plan, manage the traffic stream and demand.What is seen in this model as predicted is that, index of trip time increases in the whole network. Because by applying the limitations, the central routes of the city which presently have a special status in traffic displacement, get out of service of a considerable amount of trip demands, however the trip time in the strategic traffic restricted zone which have a great time value, decreases. Also by investigating the revenue of traffic restricted zone in 2021, the indexes obtained in a qualitative manner is similar to the pattern observed in year 2011. Reciting that utilizing the subway system will affect the trip demand and technical and functional indexes of network. In estimating and analyzing the effects of (applying traffic zone) policy for the future compared with the current situation, as this policy is not experienced before and the behavioral pattern of users and the executive ability for implementing it by the managers is not clear, only modeling is not sufficient in computing the demand. Applying this policy in base year and observation of its changes and demand distribution create a suitable field for estimating its results in the future.

Also experiments indicate that the huge traffic plans that are related with trip demand management (like traffic limitations) need public association and cooperation to reach the goal and as a result it must be so that satisfies the people’s expectations. As such applying traffic limitations at once and in a large area will undoubtedly be unsuccessful. Moreover management and executing of this plan by increasing its dimensions will cause so many challenges for the authorities of urban transportation.

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