ABSTRACT

Allocation of urban space between roads and residential area —Circular city model of traffic congestion free area—

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In recent years, roads and trains in a large city, such as Tokyo, are over-crowed by cars and passengers almost all the time. Considering the reasons from the standpoint of traffic facilities, there is little room for development of new or existing facilities in the central area of a city, which causes serious lack of capacity of the transportation system. Also from the standpoint of traffic demand, the number of trips made by a person may differ for one living in a large city and for one living in a small town, the former may usually intercommunicate each other more frequently than the latter. Therefore, the total traffic volume in a city may increase at a higher rate than its population grows.

In this paper, we planned a model of a city where the transportation facilities have necessary and sufficient capacity to pass all the trips made by the people in the city. When we consider this problem, it must be noted that the transportation system is not only a network but also consumes considerable space. Therefore, the population distribution in the city and the transportation system which has enough capacity for the trips are mutually dependent and can not be determined independently.

The model of a city to be considered is a circle Ω with radius R, where all the trips are made by the people intercommunicating each other by car, the space in Ω is partitioned into residential area and roads to form the whole city, and the portion of residential area is represented by a function $f(x)$ of position x in Ω which is to be determined. It is assumed that people populate with constant density ρ in residential area, for each pair of people a trip is made with constant probability b per unit time, and one moves from his origin to his destination along the straight line between the points. The parameter b is considered to depend on the population N in Ω as $b = b_0 N^{-\gamma}$, where b_0 and $\gamma (0 \leq \gamma \leq 1)$ are constants. This means that the number of people being met by one person in a unit time is equal to $bN = b_0 N^{1-\gamma}$ which increases as the population N increases.

Under these assumptions, we derive a functional of $f(x)$ representing the traffic volume through x in Ω, and equate it with the road area(which is also a function of $f(x)$) multiplied by transportation capacity c of unit road area. From this equation, it is derived that when radius R of the city increases but the potion of roads in the central area remains unchanged, then the transportation capacity c must be raised as $R^{3-2\gamma}$. We also solve the functional equation numerically to see the distribution of roads and residential area in Ω. In the solutions, the portion of residential area decreases radically as R increases, especially in the central area.