Analysis of the population travel behavior and its impact on the urban environment improvement

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Abstract. The article draws attention to the necessity of studying the composition of pedestrian flows and the urban areas where they form, move and disperse to improve the urban environment. In modern cities, especially megacities, most pedestrian flows participate in the transport correspondence appearance, which is due to long distances between the locations of origin and destination. A software package calculating the transport area capacity depending on the number of departees uses disaggregate models of travel demand and develops an O-D Matrix. Analysis of the results obtained allows us to assess changes in transportation demand caused by socioeconomic and urban development factors.

The term "modern urban environment" implies a common rationally organized space for city/megacity residents to live comfortably. Currently, the developed urban areas are subject to such requirements as a high level of safety, comfort, functionality, and aesthetics. A comfortable urban setting can reduce social tension, improve the quality of life, and increase the proportion of residents who adhere to a healthy lifestyle. [1].

Integrated development of modern urban infrastructure involves analyzing the composition of pedestrian flows, zones of their generation, movement and dispersion. Pedestrian flow research is due to the need for quality redevelopment in the areas where the number of residents using them is the maximum.

The required urban area functionality largely depends on the composition of the pedestrian flows. For example, when the groups with reduced mobility use the studied area, it is to have specific facilities, such as handrails, ramps, light boards, etc.

Areas, which generate and disperse pedestrian flows, are usually crowded areas, such as shopping centres, cinemas, businesses, office buildings, etc. Because of the large distances between these objects in modern cities, the residents have to use either private cars or public transport. As a result of these trips between the origins and destinations, sustainable transport links emerge, i.e. transport correspondence. In this case, pedestrian flows φ are formed/dispersed at each public transport stop, and transport correspondence ψ appear (Figure 1).

Thus, positive changes to the city living environment are to originate from the comprehensive research of the urban transport system with all its elements as a whole. The pedestrian flow composition and generation/ dispersion are not the only objects for the analysis within the framework of the Modern Urban Environment Federal Project aimed at the urban environment improvement. In particular, traffic flows redistribution over the city network, travel demand pattern, and the choice of transportation mode are essential components for reaching the Federal Project goals.
The travel mode choice is under the influence of many factors. Among them, there is the distance from the origin location to destination, the age of the pedestrian, the amount of free time he has, his physiological state, etc. Disaggregate models of travel demand are a tool for assessing the impact of external and internal factors upon the resident's travel behaviour. Since disaggregate models are models of personal preferences, their application is limited to:

• evaluating the demand for travel (Trip generation);
• evaluating the split of travel demand among the modes (Mode Split).

To study the residents’ travel behaviour in the street and road network in the city of Kemerovo, conducted surveys assessed the population travel patterns. Later a theoretically substantiated methodology was developed to estimate the capacity of transport areas depending on the number of departees from an origin. The method used the obtained disaggregate models as a basis [3].

Estimation of travel behaviour of the urban population, as a disaggregate model, has the following general form:

\[ T = F(x_1, x_2, ..., x_n), \]

where \( T \) – respondent's travel behaviour quotient, number of trips/24 h period; \( x_1, x_2, ..., x_n \) – independent (explanatory) variables of the model.

The formal representation of a disaggregate travel demand model has several forms. In particular, we can analyze travel behaviour using a linear regression model:

\[ T = a_0 + a_1 x_1 + a_2 x_2 + ... + a_n x_n, \]

where \( T \) – respondent's travel behaviour quotient, number of trips/24 h period; \( a_0, a_1, a_2, ..., a_n \) – absolute term and regression equation quotients; \( x_1, x_2, ..., x_n \) – independent variables of the model.

The model for estimating the capacity of transport areas by origin based on a disaggregate model is as follows:

– without regard to the area social set-up:

\[ E_i = N_i \cdot T_i, \]

where \( E_i \) – transport area capacity by origin, trips/24 h period; \( i \) – selected transport area; \( N_i \) – the number of residents in the transport area, ppl; \( T_i \) – average travel behaviour quotient in the transport area, trips/24 h period per person;

– taking into account the area social set-up:

\[ E_i' = \sum_{j=1}^{m} (N_{ij} \cdot T_{ij}), \]

where \( E_i' \) – transport area \( i \) capacity by origin, trips/24 h period; \( j \) – social status category; \( N_{ij} \) – the number of social group members in the selected transport area, ppl; \( T_{ij} \) – travel behaviour quotient for a social group in the selected transport area, trips/24 h period; \( m \) – the number of social groups in the area.

The area capacities by origin (formulae 3-4) are used for the calculations in the O-D Matrix [3].

The algorithm for the estimation of transport area capacity using disaggregate models includes the following stages:

• stage 1 – the collection of reference and initial information about the respondents' characteristics and characteristics of the urban population travel behaviour: the population mobility, travel patterns, travel mode choice and putting it to the database;
• stage 2 – entry of the data concerning the respondents' travel behaviour;
• stage 3 – the selection of the transport area for calculations;
• stage 4 – the regression model development and computing of the travel behaviour quotient for the selected parameters.

A software package was developed, consisting of the programme and the database to estimate the population travel behaviour. The Automated Information System for Studying the Urban Population Travel Behaviour Using the Survey Data was certified on July 28, 2010, (certificate of state registration No. 2010620404) and used for storing the initial and calculated information.

The programme starts with entering the values of the respondent's parameters, such as age, income per family member, and availability of a car in the household. The user can indicate the social status or calculate the quotient not taking it into account (Figure 2).

![Figure 2. Data Entry Form.](image)

Next, it is necessary to select the purpose of the trip, and the software package can perform calculations both taking it into account (work-related, social and recreational, business), and not dividing the trips by goals (Figure 3). Also, we can enter the duration of the respondent's travel from the origin to the destination.

![Figure 3. Choice of the Analysis Variant Form.](image)
When you indicate the city area generating the trips, first you must select the city from the dropdown list, then - the district, which is the origin. Note that quantitative parameters concerning the size of various social groups in the selected city are generated automatically from the database, which stores information for each district of each city in the form of a table. In the example below (Figure 4) you can see a fragment of the table concerning the population with the data on the number of people in each social category (senior citizens, business owners, students, employees, etc.) in each district of Kemerovo (city ID=5). The primary keys attributed to the areas of Kemerovo have the following values: Zavodsky - 1, Kedrovka - 2, Kirovsky - 3, Tsentralny - 4, Leninsky - 5, Predzavodskoy - 6, Yuzhny - 7, Shalgotaryan - 8, MZHK - 9, Raduga - 10, FPK - 11, Severnaya Mine - 12, Rudnichny - 13, Krutoy Village - 14.

If the database has no information concerning a city, the user can enter all the needed data manually (Figure 5).
The programme analyses the data collected during the survey and stored in the database. Using the entered information and the least-squares method, it calculates the quotients of the regression equation for the specified population category. The obtained regression model and the calculation results the user gets in the form (Figure 6).

![Figure 6. Results Form](image)

If necessary, the programme can perform recalculation processing other factors. Thus, it is evident that the improvement of urban areas involves not only researching the peculiar features of pedestrian flows. It is quite clear that a thorough knowledge of the transport demand pattern is an integral part of solving this problem. In large cities, pedestrian flows have an intricate link to transport correspondence, and at any public transport stop, one type of flow can transform into another. The study of transport correspondence using the developed software package allows us to track, estimate, and forecast changes in the transportation demand. Analysis of these changes caused by socioeconomic and urban development factors is undoubtedly a valuable contribution to the process of safeguarding and improving the quality of the urban living environment.

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