Methodical approaches in town-planning design of street circuits in the conditions of sustainable development of the city

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Abstract. In article the technique of adoption of the design decision on placement of eco-friendly routes for the purpose of use is proved by steady transport, the technique of the choice of the optimal solution of development of local bicycle network of routes is offered and developed structural model of the choice of options of placement of cycle routes in system of street road system and recreational zones in the conditions of sustainable development of the city. The theoretical and practical experience of construction of cycle routes in Russia and abroad is generalized; the method of the analysis of hierarchies which allows to carry out the choice of the design decision taking into account different groups of factors is used; the structural model at the choice of options of placement of bicycle tracks on the example of linear structure of the coastal city is developed; experimental design in the territory of streets of Volgograd is executed. The offered structural model is used in development of design offers of construction of bicycle tracks for the streets of Volgograd providing to inhabitants and city visitors more attractive, healthy and cheap option of movement to place of work, training, rest and entertainments.

1. Introduction

Sustainable development of the modern city is kept by development and improvement of transport system in which infrastructure of pollution-free transport with the good bicycle paths optimized for safety at the present stage of development of urban areas begins to take everywhere the significant place [1-4]. Transport systems in modern functional zoning of urban areas exist for providing social and economic relations and urban population quickly seize means of increase in mobility [5]. Transport systems make considerable environmental impact, 20 — 25% of world consumption of energy [6, 19] and emissions of pollutants are the share of them: carbon oxide, nitrogen oxide, hydrocarbons, aldehydes, groups of heavy metals, dust, soot. Emissions of greenhouse gases from transport grow in high gear, than in any other energy sector. The motor transport is also one of the main sources of pollution of free air, formation of smog in territories of the large cities and megalopolises.

The modern term "sustainable transport" is logical continuation of the concept "sustainable development". In researches of number of authors [7] this term is used for the description of different types of transport and systems of transport planning, the basic principles of steady transport system [8] are given:

- provides availability and satisfaction of needs of citizens, the companies and society with reliable movement, without doing harm to health of the person and ecosystems, promotes establishment of the principle of justice both in social groups and generations, and between them;
- is available on means, works accurately and effectively, offers means of transport at choice, maintains competitiveness of economy, and also balance of regional development;
- minimizes emissions and waste at the level of possibility of ecosystems to absorb them, uses renewable resources at the level or below rate of their recovery, uses not renewable resources at the level or below rates of development of renewable substitutes, minimizes negative environmental impacts (land and water resources, noise, thermal, electromagnetic, vibration influences).

At the present stage of development of the cities the transport system undergoes essential change: the design of urban areas, their transport communication changes, mobility of urban population increases, there is a growing level of motorization. In ecological aspect influence of transport can be reduced due to improvement of system of the pedestrian and bicycle movement on urban areas.

In social aspect positive influence of the cycle movement on extension of human life is noted, connection between favorable action of the movement by bicycles and increase in quality of life of urban population is established. Many problems of health care are solved, and investment of private, local authorities into promotion of physical activity and the device of bicycle lanes in planning structure of urban areas is considered effective from the economic point of view [9]. Special attention of town-planners to design of cycle routes and formation of the comfortable environment at transformation is undoubted in the future of the cities in Smart City [10].

More than 120 years ago construction first-ever nine kilometer paths of Coney Island Cycle Path in New York has been complete (1894, America). Now examples of creation of networks from ten bicycle highways around nine largest cities in Norway for the purpose of reduction of influence of transport infrastructure by ecology of the region [11], ten kilometer extended autobahns which roads will connect 10 western cities of the Ruhr region (Germany) are known. As specialists "valoban" consider will unload transport system of the region, having lowered traffic of car traffic to 50 000 units daily [12].

Research conducted on the example of large cities (Moscow, Russian Federation; Sao Paulo, Brazil), show that the reform of the transport system, the need for which is constantly high, with the construction of the bike path becomes a way of reducing congestion, emissions and reduction of air pollution [13].

The review of the theory and practice of construction and operation of bicycle lanes has shown that improvement of steadily developing means of transport is vital for expansion of access to economic opportunities, city ecology, to social problems of health care and tourism, doing the bicycle attractive and available to many people. In the town-planning plan issues of transport bicycle communication between the neighboring inhabited places are resolved; however justification of system of the intracity cycle movement and creation of the program of the choice of the optimal solution at arrangement of bicycle tracks on streets of different category of the city has not received confirmation yet. Research objective: on the example of options of arrangement of bicycle tracks on streets of different categories of transport network at sustainable development of the city to make technique of the choice of the most optimal solution of development of local bicycle network of routes with use of method of the system analysis – the method of the analysis of hierarchies (MAH). Research problems became: studying of theoretical and practical experience of construction of cycle routes in Russia and abroad; generalization and analysis of initial material; development of model of arrangement of bicycle tracks on the example of linear structure of the coastal city; performance of experimental design in the territory of streets of Volgograd.

2. Methods
The experiment is made in the city of Volgograd, the characterized sharp and continental climate (the low winter and high, reaching to +400 C, summer temperatures; frequent hot dry winds and dust storms during the summer period). The city is located on joint of east slope of Volga Hills and Ergeney. The North-Eastern part of Volgograd differs by pronounced fragmentation of linear landscape elements (many ravines and beams, straightened sections of river valleys, ledges with different height levels, cracks and gaps). Through 1 km Volgograd is divided by deep ravines and
mouths of the small rivers which are powerful factor in formation of relief. Slopes and terraces of Volga Hills and Ergeney are cut densely up by well-developed valley and ravine and beam network [20]. The urban area which is functionally relating to different zones is located on natural terraces. The transport and communication network has cross and longitudinal highways of different category. The apartment block is located along the Volga River, and the city is created on linear structure. For research several categories of streets are chosen: local, regional (city) and park (54% - the rivers traced lengthways; 40% - in transverse direction; 6% - other directions) which have created the bicycle network covering the city in the most demanded directions: the loaded thoroughfares; internal communications of historical and architectural monuments; places of recreation and leisure entertainment centers; objects of application of work and campuses (Volgograd State Technical University, Volgograd State University, technical schools, colleges, gymnasiums). The predesigned analysis of the chosen streets included: natural (with Photographic fixation) inspection; studying of profiles with identification of reserve territories for possible arrangement of bicycle tracks; specification of designs of strips and dendrology structure of gardening; collecting data on intensity and character of transport and pedestrian flows; existence of the electric transport (land and underground tram); functional accessory of adjacent building and places of gardening. Collected data are systematized; results of their analysis are the basis for alternative offers on arrangement of bicycle tracks in planning structure of the city

In urban design of cycle routes the set of options of their arrangement in planning structure of the city, typology of bicycle lanes is considered, transport and planning parameters of street road system, pedestrian movement and mobility of urban population in structure of the city are considered. Decision-making at the choice of optimal variant of placement of bicycle lane in system of street road system is the final stage in the course of design. The question of the choice of method of decision-making for the solution of task of placement and improvement of bicycle lane on objects of street road system or recreational zone is solved with use of analytical method – the method of the analysis of hierarchies (MAH) [14,15]. The real method is applied by the author in the scientific work [16] devoted to research of influence of vehicular noise on formation of acoustic environment in zone of crossings, in particular, to development of structural model on the basis of method which allows to carry out assessment of group of the factors exerting impact on sound level, to make adequate decisions on selection of significant factors.

The method consists in decomposition of problem on simpler components and further in processing of the sequence of judgments of the person, making the decision (PMD) in pair comparisons. Intensity of interaction of elements in hierarchy is as a result described, then judgments are expressed in number. This method includes procedures of synthesis of multiple judgments, obtaining priority of criteria and finding of alternative decisions.

At the first stage the most important elements of problem, on the second – the best way of check of observations, testing and assessment of elements come to light, development of method of application of the decision and assessment of its quality becomes the following stage. Application of mathematical model allows evaluating results of decision-making and their effect. Process of search of the optimal solution is carried out by the hierarchical principle: the results received at one of levels are used as input data for other level. The method of the analysis of hierarchies systematizes process of the solution of such multistage task [14, 15, 18].

Basis for modeling of process are the principles of identity and decomposition, the principles of discrimination, comparative judgment and synthesizing [14, 15]:

1 stage - is formulated the purpose which defines problem;
2 stage - criteria by which the optimal variant of the solution of task is selected are defined;
3 stage - generation of alternatives: some set of alternatives (objects) for the subsequent assessment is chosen.

After carrying out decomposition the problem of the choice is divided into three hierarchical levels. The hierarchy is considered full if each element of the set level functions as criterion already of all elements of subordinate level [16, 17]. After the hierarchical description of problem in the form of the
block diagram priorities of values of criteria are established, and each of alternatives taking into account all criteria is evaluated. As objects for carrying out the analysis the following is chosen: motor-road, boulevard, embankment and park.

Hierarchical representation of model of assessment of group of factors it is constructed from top (the purpose from the point of view of management is established), through intermediate levels to the lowest level which is the list of alternatives – objects of the urban environment on which options of placement of bicycle lanes are considered.

In model the full dynamic hierarchy in which each element of the set level functions as criterion for all elements of the subordinate level (figure 1) is created.

For the purpose of implementation of the principles of discrimination and comparative judgments task elements by means of matrix of comparisons are compared in pairs. The classical scale of comparative importance is applied to carrying out subjective pair comparisons [14].

The following stage of implementation of technique is the procedure of synthesis of vectors of local priorities. From group of matrixes of pair comparisons set of local priorities which express relative influence of the set of elements, on each element adjoining from above level forms.

Using the known methods of analytical planning, it is possible to receive column of relative value (or own vector of priorities) each criterion of system concerning all other criteria [14]. The last analysis stage is application of the procedure of synthesis of integral vectors of priorities. Local vectors of priorities are multiplied on priorities of the corresponding criterion at the higher level and summed up on each element according to criteria which this element influences. This procedure gives global vector of priority of element.

Figure 1. Structural model the procedure of choice bike paths on the objects of street-road network and recreational areas of the city

3. Results
The way of quantitative determination of comparative importance of qualitative factors is defined that is important as some of criteria of group of the factors influencing the choice of option of placement of bicycle lane on the urban area are practically not exposed to quantitative assessment, as was basis of application of method of the analysis of hierarchies.
The design task is considered and solved for the urban area of Volgograd within the solution of tasks of change of the transport scheme of public transport service and providing comfortable conditions of movement of the urban population in the city having unique linear planning structure and extent along the Volga River about 100 km.

As a result of conducting on-site investigations, observations and mathematical calculations quantitative and quality standards of parameters of each group of factors are received. The constructed hierarchical model includes three levels, each of which is broken into sublevels (fig. 1). In model the dynamic hierarchy in which each element of the set level functions as criterion for all elements of subordinate level is created. As a result of carrying out the analysis 14 matrixes of judgments at which extent of influence of components of group of factors – transport is evaluated, planning and factors of safety are received: at the sublevel of 2.1 – 3 criteria for evaluation of planning factors; at the sublevel of 2.2 – 4 criteria for evaluation of transport factors; at the sublevel of 2.3 – 3 criteria for evaluation of factors of safety and 4 types of subjects to placement of bicycle tracks which were in pairs compared on each of criteria. Correctness of the received characteristics, and also quality of reasoning, their logical completeness are evaluated in size of the coherence index (CI) [10], the characteristic of matrix of reasonings of \( L_{max} \) and the coherence relation (CR) value of which does not exceed 10% of IS[10, 13]. Vector of integral priorities on transport, planning and to factors of safety, calculated on each of 4 types of the considered objects, were data for drawing up matrixes of the pair relations of value by criteria of group of factors at the level of 2 and 3 hierarchies. Processing of vectors is carried out in the environment of Microsoft Excel that has allowed to range the studied objects (table 1).

Table 1. Integral indicator of influence of group of factors at choice of option of placement of bicycle lane on objects of street road system and recreational zone of the city

| Subjects to placement of bicycle tracks | Assessment of group of the factors exerting impact on the choice of option of placement of bicycle lane |
|----------------------------------------|---------------------------------------------------------------------------------------------------|
|                                        | Integral priorities | Rank |
| the trunk road                         | 0.516                | 1    |
| boulevard                              | 0.185                | 4    |
| embankment                             | 0.271                | 2    |
| park                                   | 0.203                | 3    |

4. Discussion

The Carried-out assessment of factors has shown that optimal variant of placement of bicycle lane is the motor-road in borders of crossing of streets of city and regional value (rank 1) and the embankment (rank 2), group of transport and planning factors most exerts impact on the choice of option of placement of bicycle lane, the figure 2.
Experimental design of arrangement of bicycle lanes on the most loaded trasses of the city is executed (on the example of streets of Voroshilovsky and Central districts of the city of Volgograd).
The offered method of assessment of group of factors is universal and we will easily put into practice, can be basis for preliminary selection of factors and definition of mathematical dependences. The conducted research has the continuation in consideration of questions of the transit oriented design placing emphasis on use of public transport, reduction of number of parkings, and the equipment of conveniently located crosswalks.

5. Conclusions
1. The theoretical and practical experience of construction of bicycle routes in Russia and abroad is generalized.
2. The technique of the choice of the most optimal solution of development of local bicycle network of routes with use of method of the system analysis – the method of the analysis of hierarchies (MAH) is offered.
3. The structural model at the choice of options of placement of bicycle tracks on the example of linear structure of the coastal city is developed
4. Experimental design in the territory of streets of Volgograd is executed.

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