Hexographic Method of Complex Town-Planning Terrain Estimate

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Abstract. The article deals with the vital problem of a complex town-planning analysis based on the “hexographic” graphic analytic method, makes a comparison with conventional terrain estimate methods and contains the method application examples. It discloses a procedure of the author’s estimate of restrictions and building of a mathematical model which reflects not only conventional town-planning restrictions, but also social and aesthetic aspects of the analyzed territory. The method allows one to quickly get an idea of the territory potential. It is possible to use an unlimited number of estimated factors. The method can be used for the integrated assessment of urban areas. In addition, it is possible to use the methods of preliminary evaluation of the territory commercial attractiveness in the preparation of investment projects. The technique application results in simple informative graphics. Graphical interpretation is straightforward from the experts. A definite advantage is the free perception of the subject results as they are not prepared professionally. Thus, it is possible to build a dialogue between professionals and the public on a new level allowing to take into account the interests of various parties. At the moment, the method is used as a tool for the preparation of integrated urban development projects at the Department of Architecture in Federal State Autonomous Educational Institution of Higher Education “South Ural State University (National Research University)”, FSAEIHE SUSU (NRU). The methodology is included in a course of lectures as the material on architectural and urban design for architecture students. The same methodology was successfully tested in the preparation of business strategies for the development of some territories in the Chelyabinsk region. This publication is the first in a series of planned activities developing and describing the methodology of hexographical analysis in urban and architectural practice. It is also planned to create a software product that allows one to automate the process of site assessment on the basis of the methodology.

1. Introduction
A complex terrain estimate is a result of comparison of component estimates from the perspective of usage for different purposes: for industrial construction, agriculture and forestry, for formation of residential and recreation areas, etc. Suitability of the territory for construction of buildings and structures is considered to be the most important aspect of the analysis. Town-planning terrain analysis is the basis for preparation of town-planning documentation.

Currently, the Town-Planning Code of the Russian Federation subdivides the town-planning documentation into the following types:

- spatial planning documents;
- town-development zoning documents;
- area planning documents.

Development, agreement, approval and implementation of the down-development documentation are based on the materials of relevant complex engineering surveys (topographical, engineering-geological, engineering-hydrometeorological, engineering-environmental surveys, surveys of gravel and earth construction materials and ground water supply sources), which composition depends on the type of the town-planning documentation [1,2].

The composition of the initial data forming the base for a complex terrain estimate can vary depending on the tasks considered at development of the package of town-planning documents.

In particular, at development of complex spatial planning schemes it is necessary to consider the data on territorial demography, structure of the population employment and structure of the manufacturing complex.

At development of town-development zoning documents, apart from the above aspects, it is necessary to take into account conservation and sanitary protection areas and borders of the land use and cadastral registration.

At the level of area planning documents the aspects of design engineering and such town-development restrictions as insolation, aeration, influence of harmful factors, presence of other restrictions, become important [3,4].

The obtained initial data form the basis for preparation of maps and schemes containing the information on presence of specific land use restrictions, both in the scale of the spatial planning documents and town-development zoning and area planning documents. An example of a fragment of such complex terrain estimate scheme is presented in figure 1.

At development of the draft general layout of Kaigorodovo village in Sosnovka district of Chelyabinsk region the following factors were taken into account as restrictions:
- presence of the first, second and third belt of the water protection area of the Miass river;
- risk of area flooding in case of emergency;
- presence of protective areas of utility networks;
- presence of fire barriers from the forest areas and state forestry fund lands;
- presence of capital structures and land plots of different forms of ownership on the territory.

![Figure 1](image-url)

**Figure 1.** Fragment of the draft general layout of Kaigorodovo village in Sosnovka district of Chelyabinsk region. Scheme of town-development restrictions. (supervisor A Ju Khudyakov, Arkhikon LLC) [5,6].
The complex of restrictions formed the basis for establishment of the architectural-planning structure of the population center [7]. In this regard, it should be noted that at formation of the complex estimate scheme it is not necessary to estimate the factors, which do not affect the proposed structure and specific land use.

The educational practice of architects and town planners includes factors, which actively influence the planning structure at creation of complex projects. The town-planning analysis system is comprehensively considered in such works as “Complex Regional Planning” (V N Belousov, V V Vladimirov) [3], “Basics of Spatial Planning of the Russian Federation” (M Ya Vilner) [4], the modern town-planning practice is covered in manual “Modern Theory and Practice of Town-Planning: Spatial Development of Settlement” (V A Kolyasnikov, V Yu Spiridonov) [2].

Based on the accepted practice of making complex terrain estimate schemes and the own elaborated experience, the author’s procedure for estimate of the area potential by the hexographic method has been developed and received practical approval.

The standard methods of terrain estimate assume plotting of restrictions in the form of geographic or special signs, zonal hatchings or borders designating the beginning or termination of the influencing conditions of one or another factor on maps and schemes.

![Figure 2. Hexagonal mesh [8].](image)

The hexographic method assumes plotting of a conventional mesh on the map or a scheme, which consists of hexagons of a regular shape, i.e. a cellular structure (figure 2). The size of the hexagons (hexes) is chosen randomly, depending on the map scale, availability of a sufficient amount of initial data, required imaging precision of the research materials.

A display item in this procedure is a hexagon colored in accordance with the adopted conventional signs, wherein the degree of the gradient density gives evidence of the distinct manifestation of one or another studied factor. The hexographic method is firstly used for making of standard schemes of restrictions by different negative factors. Each cell of the estimate scheme acquires an estimate index from -10 to +10 (depending on the degree of manifestation of the studied property), wherein the degree of manifestation of a negative property increases its deviation from normal “0”. Thus, the maximum negative factor is expressed by index -10.

This procedure also allows to consider positive factors, such as aeration, soil bearing capacity and even aesthetic factors, scenery, landscape characteristics, as well as social context. The number of estimate schemes is only limited by the task posed by the designer.

The result of the junction of estimate schemes is a complex terrain estimate scheme, which does not only consider the restrictive factors for the design territory, but also positive town-planning, aesthetic and social factors. The complex estimate is a map of the territory with a hexagonal mesh applied thereover, which cells comprise a mathematical composition of all the indices obtained as a result of the estimate of individual factors. In this regard, it is understood that the maximum
mathematical value reflects the highest town-planning territory potential, and the minimum value – a territory with the least town-planning potential. The overall scheme is exemplified by the development project of Karabash made under the auspices of the author in the South Urals State University (figure 3).

Figure 3. Concept of the general layout of Karabash. Complex terrain estimate scheme (student D D Grigorieva, supervisor A Ju Khudyakov) [9].

The potential of the graphic method [10] of the design area analysis allows to solve several tasks, which are increased at the modern complex design engineering:

- to make a complex estimate of natural and technology-related factors influencing the territory development;
- to make a scheme of restrictions, which does not only reflect the restrictive and negative factors but also factors comprising an efficient, positive resource of the territory;
- to make schemes of a complex analysis of an unlimited number of factors, reducing them to a uniform model;
- to make a complex estimate of social, subjective-evaluation, aesthetic factors influencing the territory development.

The hexographic method is the most flexible tool allowing to transfer conventional schemes of town-planning restrictions into graphic images, which are easily perceptible by a non-specialist. The
general availability of the displayed information allows to bring the special information to a wide circle of users.

One of the advantages of this method is an ability to define, based on the estimate representational schemes, what factors are primary drivers of the territorial development and what factors are subject to adjustment. Based on the graphic schemes, it is possible to make road maps on development of the territory potential in view of the local characteristics.

For illustration the scheme of Chelyabinsk-Yekaterinburg agglomeration development potential based on the hexographic analysis method was presented during the round table held by the National Association of Researchers and Design Engineers in Chelyabinsk in December 2016 (figure 4). The scheme of the complex terrain estimate of Chelyabinsk and Yekaterinburg agglomerations [11] was made within the framework of the graduation qualifying paper under the auspices of the author (student A A Malova).

![Figure 4. Fragment of the scheme of complex terrain estimate of Chelyabinsk and Yekaterinburg agglomerations (student A A Malova., supervisor A Ju Khudyakov) [11,15,16].](image)

2. Conclusion.

The article generalizes the empirically obtained material of studying the abilities of the graphic town-planning territory potential analysis. As a result of the generalization, the author has offered a procedure of applying an index binary hexagonal mesh on the base material. The mathematical comparison of numeric indices and their further display on the overall scheme gives a numeric equivalent expressed in the density of the color filling, which does not only reflect the restriction but also the degree of its influence on the town-planning situation. The hexographic method is of interest for making of complex terrain estimate schemes and can be compared to the triangulation method of building the map material.
The theoretical value of the method lies in a wider range of the information display on the maps of town-planning documentation as compared to the conventional graphic analysis methods, as well as display of additional factors, which influence the territory potential.

The practical value of this method lies in the ability to use the results of the graphic analysis researches at public consideration of the town-planning documentation, in the educational process, at making of analytical schemes for town-planning and object development.

A line of the further scientific research can be creation of a binary system-based special curve reflecting the potential of the town-planning territory development. The special method of the territory potential modeling will not only allow to visually display town-planning restrictions and advantages but also to apply mathematical matrices reflecting the emotional perception of the design territory by the town planner on the map material.

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