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SYSTEM APPROACH AND MATHEMATICAL MODELS IN THE SOLUTION OF TOWN-PLANNING PROBLEMS

The article describes the application of a system approach and mathematical models in the solution of town-planning problems.

Keywords: mathematical model, town-planning research, system approach, system-structural analysis.

Formulation of the question. Difficulty in solution of town-planning problems in real design practice is aggravated by the fact that in the design process, essentially, every time you have to define the optimal variant of the project on the whole complex of issues faced by architects, engineers, subcontractors, economists and others, and find the only appropriate solution for this task to design the city, in these particular circumstances. Each project of the General plan of the city has its own unique identity, its individual face; not only typification of decisions, but even any reasonable classification is not applicable here. This is a specific feature of town planning, which distinguishes it, its goals, methods and degree of complexity from design, for example, industrial or residential and public buildings, which, in turn, have their peculiarities.

Mathematical design is an experimental-theoretical method of cognitive and creative activity, and also investigation and explanation of phenomena, processes and systems on the basis of creating new objects - mathematical models [6]. This is an effective way of solution and analysis of tasks. It gives an opportunity to unite the disparate elements in a system with a logically justified relationships. The interpenetration of different fields of knowledge, with the possibility of a symbiosis of involves Sciences happens during modeling. The mathematical model is an efficient way of cognition of the phenomenon, forecasting and management of its development.

The objective. At the present stage town-planning forecasting and projecting is associated with the use of special calculations aimed at taking account of demographic, socio-economic, environmental, territorial, and other factors affecting the development of the city. The complexity and diversity of urban processes do not

allow the adoption of town-planning solutions on the basis of a single, comprehensive mathematical model of the city.

The main part. Methodological basis of computer modeling is a system analysis. The dominant trend today is not an opposition but the interpenetration of all types of simulation, the symbiosis of different information technologies in the field of modeling.

Every year the complexity and the scale of the objects of architectural and urban design increases. In turn, it causes the complexity of forms, methods and organization of the actual process and design technologies, in the basis of which modern scientific theories and methods are increasingly incorporated. In the conditions of extraordinary expanding of scale of the architect and city planner activities, the role of architectural science increases. Like any other fairly developed scientific discipline, it must provide the ability to predict the behaviour and development of the designed object and show the possibility of the effective implementation of the purposeful control impacts on these objects, whether individual buildings or city and settlement systems.

In this regard, the systematic approach to the study and design of complex objects is in the foreground at the moment. Systematic studies are being increasingly used in all fields of science and technology. Therefore, the need to learn the basic concepts and methodological principles of the system approach to the field of architectural design is quite clear.

The main methodological principles of structural and system analysis are differentiation and the partition of the analyzed system on its subsystems and primary elements and the establishment of all forms of functional interrelations between them.

When using a system approach we can identify five major steps or stages of carrying out structural-system analysis of the object. The procedure and composition of research procedures may vary depending on the nature and complexity of the projected facility, availability of all necessary data, and also methods used in this work, equipment and techniques.

The first stage of work can be defined as «stage of a General formulation of the problem from the point of view of definition of the main indicators of the volumetric-spatial structure and the nature of functioning of the system which is being designed. It is important to have an exact understanding of the objectives of the work, thoroughly thought-out choice of the basic system-forming signs and corresponding optimality criteria. At this stage it is necessary to present the problem in perspective and to provide, if possible, a priori estimate of expected results.

At *the second stage* the main task is to develop a working hypothesis in accordance with the selected objectives and criteria, and the selection of methodological tools of problem solution. We need to strive to express all aspects of

the operating system in quantitative form. After that it becomes possible to choose of those or other means of mathematical, logical and structural modeling.

The third stage is defined as the differentiation of the system into its component parts. An important feature of this stage is the classification of the subsystem and the structural elements so that on the basis of logical division we could quantify the impact of their characteristics and indicators on the entire system and to identify the nature and extent of this influence with various changes of indicators subsystems and elements.

The fourth stage is to test the system. There are experimental calculations and analysis of the system behavior when changing external and managing influences on it; after that an optimal control and regulation system of the city can be set.

Final *fifth stage* – the development of concrete recommendations for the implementation of the results of the problem solution. At all these stages in the process of implementation of structural-system analysis the whole arsenal of tools provided by cybernetics, modern mathematical methods and computer software is widely used.

Complex problem of choice and functional zoning of territories for the construction of new cities is connected with the necessity to solve a number of technical, economic and planning problems using mathematical methods and means of modern computer techniques.

The calculation of the baseline and mathematical model of a structure definition of housing on the first stage of construction take into account the possibility of calculation of capital investment, as well as setting separate restrictions on new housing construction and major renovations. In the calculation of baseline information the quantitative account of the factor of time through the coefficients regulatory comparative effectiveness and bring temporal costs is provided. Additional evaluation of the factor of time is provided by taking into account the dynamics of growth of comfort living conditions in areas of existing building in stages of prospect.

The assessment of reliability of the obtained results of calculations should be performed with account of possible errors caused by: random nature of this particular part of the initial information, the inevitable simplification in mathematical models of real processes of the development of towns, possible errors of account. In some cases, in conditions of insufficient completeness of the initial information, you can use the integrated indicators and limit the number of considered factors. It is also necessary to take into account different degrees of accuracy of basic information.

The main indicators, which represent the source of information for the mathematical model are: the number of people that can be accommodated on the territory of the planning area, as well as the number of inhabitants living in the area

of the existing building on the current year; the area of the planning areas, differentiated by types of houses; capital investments, absolute and specific; operating costs; the coefficients of the comparative effectiveness of capital costs and bringing multi-temporal costs; volumes of course demolished and of course the support housing fund in the planning areas.

Joint review of the indicators of urban construction and related industries allows to reveal the relationship and quantitative relations between them and non-industry results of consistent improvement of the urban plan.

Further development of the ideas associated with the use of the mathematical apparatus of linear programming for solving problems of residential development is its applied use in the design and feasibility study for the reconstruction of districts of the old, low-rise building in existing developing cities. Using the simplex method of linear programming in a number of design and research organizations of the urban construction practical issues were being solved. They were related to reconstruction of large tracts of old residential building of cities.

The inclusion of the methods of mathematical modeling in the process of designing provides essential quality, realism and shortening of the design decisions. The success of mathematical models depends greatly on how informal, in essence, process of project development may include formal description methods. It follows from all of this, one of the preconditions of necessity of develop projects and schemes of regional plan on a systematic basis, as one of the tasks of system analysis is to learn to combine formal and informal methods of analysis, mathematical methods with the heuristic techniques of experts.

The main working method adopted currently in the design organizations of the urban construction in the development of general plans of cities is the so called alternative engineering. The presence of many different factors that should be considered in the development of master plans, and contradictions existing between them, lead to the necessity to consider in the design process several variants of design solutions in whole or in part, differing among themselves, in addition to the general compositional ideas and concepts, the techno-economic, functional, and other qualities and characteristics. Complex estimation of variants of design solutions, their comparison on this or on different criteria, or on the corresponding system of indicators allows you to select the relatively best option of design decision. The problem in this case is the lack of confidence that in the comparison of a limited number of options really the best, optimal solution has been among those considered. Moreover, it can be argued that in the multifactor conditions and related laws of combinatorics by uncontrolled growth in the number of potential solutions the most optimal variant of the project, most likely, escapes from a field of view of the designers. From here, actually, follows the urgent need to develop a scientifically

based methodology and principles of optimal design, the solution of which is possible only with the wide use of advanced mathematical methods and computing.

One of the peculiarities of the process and methods of urban planning is its distinct complex character, due to which there are several aspects of the review of the same draft plan of the city. Thus, the design process appears as though divided into several subject planes, usually called as parts of a project, referred to individual branches of town-planning projecting.

It is conditionally possible to allocate the following seven main parts (or sectors) design: territory; engineering equipment and improvement; industrial areas; urban traffic and transportation; residential development; system of cultural-consumer services; recreation area.

The selection of industries for town-planning design, reflecting specifically subject-specific segmentation of the content of the project material, caused, in turn, narrow specialization of the designers of relevant profiles. The presence of narrow specialization of project workers and the «branch» approach to the methods and organization of design process has its advantages and disadvantages.

The advantages are connected, apparently, with a higher level of professional knowledge and skills of the designers of the relevant profile, which allows to receive as a result of designing effective solutions. At the same time industrial specialization which occurred in practice of designing leads to a number of serious drawbacks, among which in the first place should be highlighted: the lack of interconnectivity between different sectors of design, absence of integrated assessment criteria and selection of optimal variants of design solutions and the related experience determine the best overall solution according to the system of private, branch criteria, which are, in most cases, not reducible to each other.

Elaboration of technical-economic basis of development of the city has as its main objective the development prospects of the city, the principle scheme of planning the structure and principles of architectural-spatial composition of the city. In addition, this document identifies the calculated number of population, the measures on engineering territory development, outlines the levels of cultural service for the expected life of the plan and on the first stage of construction. Special attention is paid to analysis of technical and economic efficiency of the adopted areas of city development, land use, rise design and planned volume of reconstruction works. The placement of the major functional areas of the city, the placement of urban and district centers, designing a network of main city highways, bridges and overpasses, engineering equipment are shown, as a rule, in the sketch of the general plan.

The project of placing the first stage of construction is developed as a part of the general plan and mainly serves for determination of the amount and placement of all

types of construction, planned for the period of 5-10 years and carried out on the territory of the city in accordance with the data of plan bodies and municipal organizations.

The project of detailed planning and architectural study of the building are also being developed on the basis of materials of the general plan of the city with respect to individual parts of the residential areas. The main purpose for this is the establishment of architectural and spatial design of the built-up territory and determination of the layout scheme of the projected area in the city, plan of the red lines and the construction sketch.

The development project is designed, as a rule, on the basis of the draft detailed plan with respect to individual micro-districts, blocks and groups of houses, and also for the construction of community facilities. The development project is developed in two stages: the project specification and drawings.

The natural consequence of such fragmentation of stages and phases of design, due to the high degree of complexity of the object design and versatility, is the need for repeated refinement, drill and specificity of all project decisions as a whole and all its constituent elements as well. This, in turn, leads to a peculiar, iterative in nature, process of architectural design with the consistent growth of the extent and scope of consideration of the design solution at each stage.

The conclusions. Development of general plans of new and projects of development and reconstruction of existing cities (town-planning design) is the major urban area, in which the prospects of development of the city and comprehensive solution of all its structural elements and functional areas are defined and elaborated, taking into account trends of planning as well as social and scientific-technical progress. The need to develop a scientifically based methodology and principles of optimal design, the solution of which is possible only with the wide use of advanced mathematical methods and CAD.

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РЕЗЮМЕ

СИСТЕМНИЙ ПІДХІД І МАТЕМАТИЧНІ МОДЕЛІ У ВИРІШЕННІ МІСТОБУДІВНИХ ЗАДАЧ

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Ключові слова: математична модель, містобудівні дослідження, системний підхід, системно-структурний аналіз.

На сучасному етапі містобудівне проектування та прогнозування пов'язані з використанням спеціальних розрахунків, спрямованих на облік демографічних, соціально-економічних, екологічних, територіальних та інших факторів, що впливають на розвиток міста. Складність і багатоплановість міських процесів не дозволяють прийняття містобудівних рішень на основі однієї всеосяжної математичної моделі міста.

Кожен проект генерального плану міста має свої неповторні риси своєрідності, своє індивідуальне обличчя; тут не застосована не тільки типізація рішень, але навіть яка-небудь обґрунтована класифікація. Саме в цьому полягає специфічна риса містобудівного проектування, що відрізняє його за своїми цілями, методам і ступенями складності, від проектування, наприклад, промислових або житлових і громадських будівель, що мають, у свою чергу, свої особливості.

Математичне моделювання виступає теоретико-експериментальним методом пізнавально-творчої діяльності, а також методом дослідження і пояснення явищ, процесів і систем на основі створення нових об'єктів – математичних моделей. Це ефективний спосіб вирішення та аналізу задач, що

дозволяє об'єднувати роз'єднані елементи в системи з логічно обґрунтованими взаємозв'язками.

РЕЗЮМЕ

СИСТЕМНЫЙ ПОДХОД И МАТЕМАТИЧЕСКИЕ МОДЕЛИ В РЕШЕНИИ ГРАДОСТРОИТЕЛЬНЫХ ЗАДАЧ

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Ключевые слова: математическая модель, градостроительные изыскания, системный подход, системно-структурный анализ.

На современном этапе градостроительное проектирование и прогнозирование сопряжено с использованием специальных расчетов, направленных на учет демографических, социально-экономических, экологических, территориальных и других факторов, влияющих на развитие города. Сложность и многоплановость городских процессов не позволяют принятие градостроительных решений на основе одной всеобъемлющей математической модели города.

Каждый проект генерального плана города имеет свои неповторимые черты своеобразия, свое индивидуальное лицо; здесь не применима не только типизация решений, но даже какая-нибудь обоснованная классификация. Именно в этом заключается специфическая черта градостроительного проектирования, отличающая его, по своим целям, методам и степени сложности, от проектирования, например, промышленных или жилых и общественных зданий, имеющих, в свою очередь, свои особенности.

Математическое моделирование выступает теоретико-экспериментальным методом познавательно-созидательной деятельности, а также методом исследования и объяснения явлений, процессов и систем на основе создания новых объектов – математических моделей. Это эффективный способ решения и анализа задач, позволяющий объединять разобщенные элементы в системы с логически обоснованными взаимосвязями.