Comprehensive assessment of options for renovation of buildings and city blocks

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Abstract. The study contributes to infographic approaches when providing comprehensive assessment of city areas during reorganization. It presents infografic models and prospective tool for infographic modelling, visualization, analysis and quality evaluation. The object of study is infographic model of "renovation" options of city blocks. The term "renovation" has been actively used in the directive documents and Decrees of the Government of Moscow from 2005 till nowadays. The task of the study was the development of methods for assessing the diversity of parameters of demolished, reconstructed and newly erected buildings and structures of housing stock and social infrastructure. Method that has been used in the study was structural modification of the basis infographic model presented in the article. Conclusions of the study show that a "star" multilayered infographical model produces good results when evaluating the quality of urban area "renovative" variants and it proposes R-language as a development tool for such future models. Also, the study has indicated to the fact that city environment began to be evaluated not only as a socio-technical, but also as a cyber-physical system.
Key words: assessment, renovation, quality, building, cyber-physics, R-language, visualization

1. Introduction

The problem of reconstruction (urbanization) of territories of different countries (including urban areas) seriously worries humanity since the beginning of the twentieth century. It was then that the need to replace (renovate) the physically or morally worn out housing and relocate the residents of demolished buildings and structures rose in full growth and continues to accompany the city territories all over the world, without reducing its heat. Approximately from the middle of the twentieth century, statistical studies of the processes and results of such a reorganization are constantly carried out.

The need to maintain the old housing fund becomes so expensive that it is advisable to demolish it and build it up again. But city authorities cannot afford such kind expenses in full amount.

The relevance of this article is that the major cities of Russia have been allocated funds and it is necessary to take an optimal decision based on the parameters of what is going to be demolished and what will be built, and also on the basis of the social criteria of rationality. This should be a comprehensive integrated assessment. This means the need to evaluate the quality of options for reorganization for a very large number of parameters.

The idea of renovation, as a reorganization of city areas, and the term "renovation" were proposed at the Moscow State University of Civil Engineering at the peak of the period of "dotted construction" of the existing town-planning composition of the city of Moscow at the turn of the 20th and 21st centuries. This idea was borrowed from the world practice, which considers the consolidation of urban areas as one of the ways to reduce their spatial growth and the associated environmental impacts. The idea was actively supported by the authorities and Mayor of Moscow Luzhkov Yu. M., and the term "renovation" was included in the directive documents and the Moscow Government Decrees of that period.

Researchers note significant differences between the diagnostic values of indicators in different regions of each country. After the dismissal of the Mayor of Moscow, Luzhkov Yu M in 2010, the idea of total "dotted construction" and "spot development" was criticized, its popularity and intensity of use had been decreased significantly. Recently the term "renovation", the content of which is not directly associated with the idea of "dotted construction" of city blocks, once again has acquired relevance in the activities of the Moscow Government, which is explained by the need to significantly improve the level and quality of life of the population. "Renovation" is now understood as a complex problem, combining new construction, reconstruction and renovation, social and transport aspects of life and work, demolition of buildings and structures at the end of its lifecycle, construction waste recycling and organizational and logistical issues of resettlement of Muscovites as well.

Therefore, the development of scientifically substantiated and coordinated with the population plan of renovating the Moscow urban areas for the coming decades is an urgent point.

2. Methods

One aspect of the scientific justification for such a renovation program is the development of methods for assessing the diversity of parameters of demolished, reconstructed and newly erected buildings and structures of housing stock and social infrastructure. The results of the assessment and forecasting of certain characteristics at the level of global governance should be reduced to integral assessments of the quality of the construction sites themselves, as well as the construction, operation, reconstruction and demolition of the organizational and technological processes of the construction industry.

In other words, we are talking about the advisability of using infographic models of the convolution of a variety of parameters for the integrated evaluation of variants of Moscow city blocks renovation.

Publications of foreign authors, as well as the results of international forums are devoted to the most common a method of reducing the spatial growth of urban areas - the problem of their "compaction" [1–14].

Russia's building science is actively studying the problem of "reorganization" (rearrangement) of urban areas, as evidenced by numerous publications in domestic and foreign professional publications, as well as dissertational research [15–27].

These researchers systematically have been analyzing, competing with each other, different types of reconstruction in the construction industry. This article is devoted to continuing research on this topic.

The abovementioned transformation of semantics of "renovation" term indicates that socio-technical status of a city has changed. Processes of information technologies implementation, trends of common data environment (CDE) and digital economics development have led to the fact that city environment began to be evaluated not only as a socio-technical, but also as a cyber-physical system [28].

It is obvious to authors that in order to improve the quality of the integrated evaluation of options of Moscow city blocks, specific methods of data representation and visualization should be used.

Approaches are just starting to be developed to understand cyber physics of urban buildings life cycles and of a city as a whole [29, 30].

Domestic terminology for determining the cybernetics of building systems is also in the process of design [31].

The basic infographic model is the basis of the systemic scientific study of traditional (repair, reconstruction, restoration) and innovative (renovation, reversion, recombination, retrieval, etc.) types of construction, methods and processes of their use in construction as shown in figure 1.

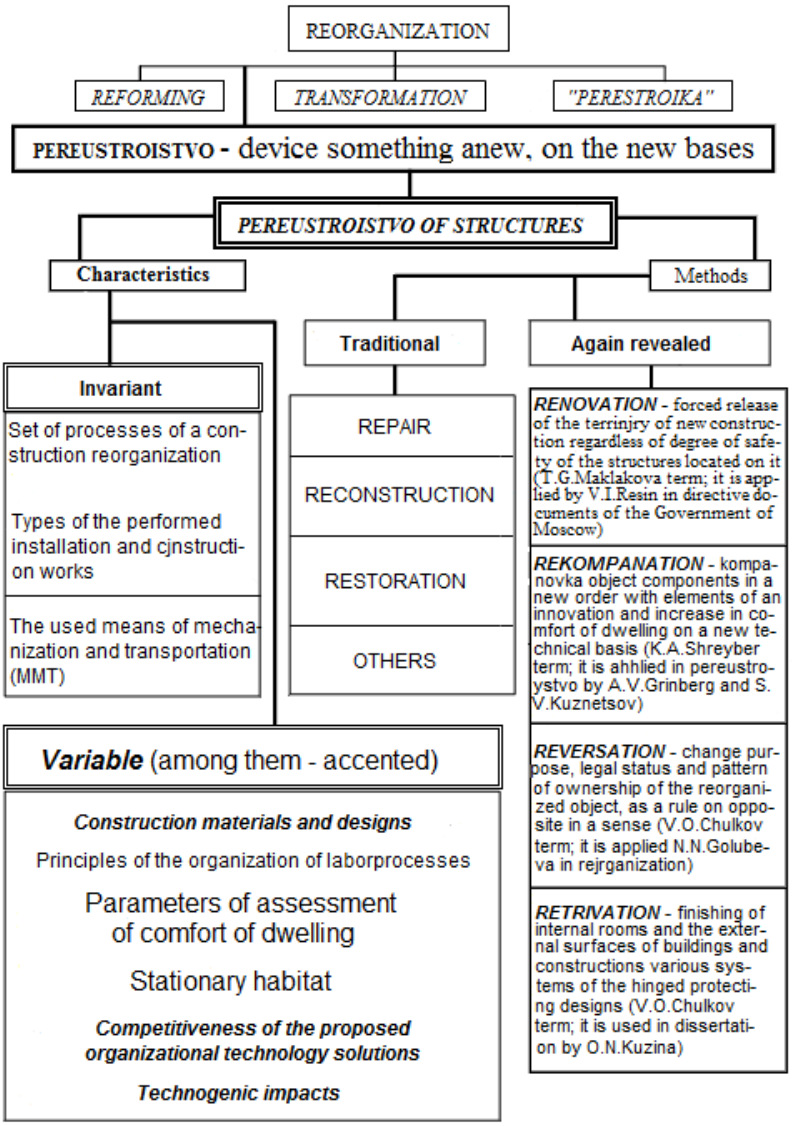

Figure 1. Types of reconstruction in the construction industry [26]

Over the past decade, the world's surface has been reorganized to 1000 km^2 every year, including construction reorganization. Up to four percent of the total number of demolished, erected and reorganized construction sites falls on previously used or already mastered territories for secondary use. This is one of the ways to further reduce the newly developed territories, which characterize the cramped spaces of construction sites, the need to take into account the number of risks and their insurance that is much greater than when developing new territories. The consequent and constantly increasing intensity of air and soil pollution, also associated with a steady increase in the number of

vehicles and the complexity of restricting their use, adversely affect people's health and quality of life, increase the level of excessively generated heat. The parameters and characteristics of each of these processes in the society are constantly changing dynamically in the process of their interaction, which requires the development and use of adequate methods, technologies and tools for their diagnosis and monitoring.

3. Results

The variety of values of such parameters of different characteristics of independent and interconnected processes occurring in the construction industry are monitored and analyzed within the framework of operational management by construction. For a global (strategic) management of construction production of design and implementation of renovation of residential urban areas (in particular, in the city of Moscow), it is necessary to perform a reliable integrated assessment of the quality of renovation projects and the processes of its implementation.

When implementing the program of renovation of Moscow's neighborhoods, it is important to choose such a variant of the renovation project for a particular quarter that will ensure its best overall performance. In the preparation of renovation projects, developers consider a number of indicators, some of which have directive fixed values, and the values of other parameters can be varied by the designer in order to achieve the best results of renovation in the context of specific external conditions, the circumstances of the renovation and the limitations that have been adopted.

Thus, already at the stage of developing a renovation project, one can make a prediction about its results based on the application of a flat infographic (visual) model of "folding" the variety of parameter values characterizing the quality of renovation results and the processes of achieving them as shown in figure 2.

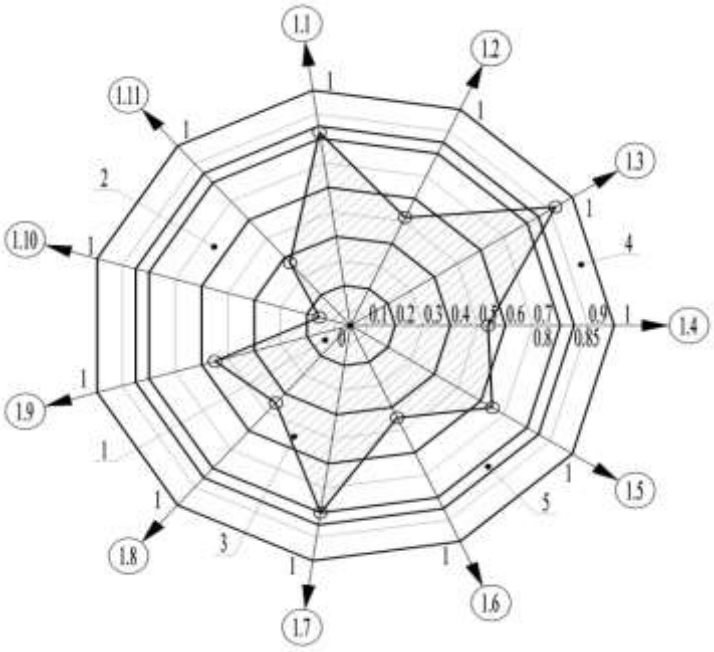

Figure 2. Flat infographic model of "convolution" of the parameters of the object of investigation [16]

The model is executed in the right polar coordinate system, that is, the axes (the number of which corresponds to the number of the investigated parameters of the research object) are arranged clockwise, and the sequence of axes corresponds to the "weight" (significance) of the parameter, which is determined by the expert method. The number of axes of the model is unlimited, each axis must be graduated from zero to one (for example, axis 1.4 in figure 2). If necessary, special zones (for example, zones 1, 2, 3, 4 and 5 in figure 2, which are shown on the callouts).

By connecting successively points on neighboring axes, we obtain a polygon whose area is taken as the integral estimate of the quality of the renovation projects.

Each renovation project has a number of options for combining the values of the original parameters. We set the task of determining the combination that will ensure the best values of the final indicators of renovation and will allow making an informed choice in favor of a specific version of the renovation project.

To do this, the numerical values of all model parameters must be divided into three groups:
- directional fixed values;
- variable values for each variant of the project, which are set by the designer in the framework of existing or accepted by this designer constraints;
- derived values for each version of the renovation project, which are calculated according to the previously developed mathematical formulas.

Parameters within each of the last two groups should be divided into two subgroups:
- striving to minimize their values;
- aspiring to the maximum of their values.

In each subgroup of parameters and their numerical values, we select the minimum or maximum numerical values for the parameters of each denomination, which we take as unity. For the remaining values of the parameters of each denomination, we find their dimensionless quantities (less than or equal to 1) relative to the minimum or maximum value, respectively. All parameters (variables or derivatives) receive dimensionless values of Pi (i = 1, ..., n) on the interval [0,1], where n is the number of parameters considered for the renovation project variant. The received priority sequence of parameters, as was indicated above, determines the ordinal numbers of the axes of the infographic model of "convolution", on which the relative values of the corresponding parameters will be plotted. Thus, the number of axes of an infographic model of convolution will be equal to the number of n names of variables and derived parameters, and the sequence of their location in the model relative to each other will not be arbitrary, but will be chosen by the customer (or developer) consciously.

The infographic model of such a "convolution" (figure 2) is a system of n> 2 coordinate axes with a common origin and angular pitch of 360/n (degrees). On each of the axes separate segments are plotted, graphically displaying the reference values of the corresponding parameters. The ends of the adjacent single segments are joined by straight lines, resulting in a flat reference polygon.

On the axis corresponding to a certain parameter, its value Pi is postponed. By connecting in similar fashion the ends of Pi of neighboring segments, we obtain the actual polygon. Each variant of the renovation project will have its own actual polygon on the convolution model.

The ratio of the areas of the actual and reference polygons characterizes the quality level of a renovation project, which is related to each other.

4. Discussion

In the domestic construction science, the considered flat infographic models is called "star" [16]. The models have been using in studies of multi-component and multi-parameter systems of the construction industry of the former USSR and Russia.

Subsequent studies confirmed the wide possibilities and unlimited range and application of "star" infographic models [26].

This class of models is widely used in the economy (where they are called the "Kiwiat diagram"), on transport (they are called "a portrait of object of interest"). The scope of application of these models is constantly expanding due to the simplicity and speed of their use in computer information technology. These models can be multi-layered as shown in figure 3, they are used for research objects that have a multifaceted characterization and application areas, for example, when reorganizing the territories of former industrial enterprises.

It is proposed to deduce the infographic models from a local application to a wide use.

The given models could be transformed into a package of R-language. R is an open source language and environment for statistical computing and graphics. It is preferred to presume of it of an

environment within which analytical techniques are implemented. R can be extended via packages (tidyverse, ggplot2, dplyr, tidyr, purrr, readr roxygen2, testthat, devtools, etc.). There are many packages are available through the Internet sites. R is an integrated suite of software facilities for data manipulation, calculation and graphical display. One of the purposes of R-language is multifaceted data representation and visualization in complex systems as well [32].

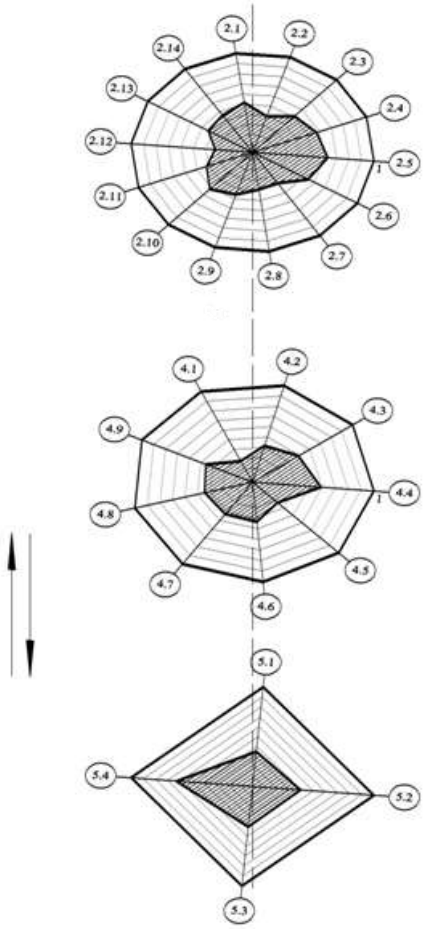

Figure 3. A multilayered model of the "convolution" of the parameters of the object of investigation when renovating and reorganizing the territory of the ZIL car factory in Moscow [25]

One of R's strengths is the ease with which providing compressed pivot data outlining the identified trends in the data set. In other words, R-language is a useful tool for modelling, visualization and analysis.

The complexity of the coverage of all aspects of renovation, as a multi-layered and multi-parametrical cyber-physical and socio-technical system, presupposes an examination of the significant diversity of individual characteristics, revealing the degree of their significance and interrelationships, requiring the development of new information technologies. The use of such technologies is able not only to interconnect individual characteristics, to perform diagnostics and monitoring changes in the quantitative values of individual parameters, but also to operate with integral assessments of the interaction of all the above-mentioned aspects of renovation. Domestic construction science pays serious attention on the creation and application of "folding" models for certain parameters and characteristics into integrated comprehensive assessments. It allows to operate with such data on different management levels when assessing the quality of processes and performance results. One of the varieties of such models is considered.

5. Conclusions

1. In order to provide comprehensive assessment of urban area renovation evaluate results and provide results of its implementation, as form of cyber-physical system activity, it is advisable to use a "star" multilayered infographic model, considered in the article. It represents the continuity of multi-component and multi-parameter systems studies have been developing in the construction industry of the former USSR and Russia.

2. The study proposes R-language as such future models development tool. It is proposed to transform flat and multilayer "star" infographic model into a package of R language in order to use the advantages of the language environment and put the models into common international level of data analysis for renovation of buildings and city blocks.

3. Also, the study has indicates to the fact that city environment began to be evaluated not only as a socio-technical, but also as a cyber-physical system.

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