Methodological approach to the classification of areas of compact built-up development areas for selecting variants of actions and sequence of technical and technological solutions for the renovation of these areas.

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Abstract: - The paper proposes to classify the compact built-up development areas, including their components: buildings, constructions, parks, engineering networks and others by the combination of consumer properties. At that, the compact built-up development areas, designed for living and life activity of people, according to the system approach, are represented in the form of a system - namely, a system complex city planning formation. Technical comfort of these areas is taken as an integral indicator of their consumer value. Technical comfort is considered as comfort of technical building of the environment of society and is evaluated by a degree of compliance with sanitary and technical norms, rules and safety standards of this environment, and other factors. It is proposed to numerically evaluate the technical comfort of compact built-up development areas by the total characteristics of their physical and moral depreciation. The paper presents the detailed and specific set of individual techniques, providing the classification of compact built-up development areas. Based on this classification, a set of actions for renovation of these areas and their member objects is proposed. Represented is the rational sequence of making technical and technological decisions that implement the series of actions for renovation of compact built-up development areas. As an example, the features of development and choice of variants of technological decisions for repair of individual objects of these areas are considered. The selection is made with the minimum resource consumption for a particular method of implementation of the considered technological variant of repair.

Key-Words: Methodological approach, classification, consumer properties, city-planning formation, moral depreciation, physical depreciation, technical comfort, reorganization, actions, technical and technological solutions, variants.

1 Introduction

Within the market economy context significant real estate price fluctuations are possible and probable. Thus another system (different from the monetary system) of evaluation and classification of objects of Compact Built-up Development Areas (CBDA) including buildings, constructions, transport and engineering infrastructure, etc., which provides an ability to make effective management, organizational and technological solutions to their maintenance and reconstruction, might be in demand.

That kind of system should have a distinct objectivity and stability in comparison with the stock market cyclic swings by the monetary evaluation of real estate prices.

In the paper [1] a dwelling (an apartment, a private house) is offered to be evaluated according to the set of its consumer properties: its spatial-planning parameters, its structural systems and construction materials, architectural and aesthetic properties, engineering systems and equipment, ecological and hygienic characteristics, etc. It is indicated that each above-mentioned group includes a variety of consumer properties, each of which may be described ambiguously, which in its turn repeatedly expands the range of ideas about a consumer level of each dwelling.

Author [1] puts forward an idea of dwelling categorizing (starting with the 1st category of luxury dwelling to the 4th category of social dwelling) using the quantitative indicators of upper and lower limits of the total floor area of apartments with the number of rooms from 1 to 6. Qualitative indicators of a certain dwelling category include, in accordance with table 2 [1]: beautification of site development, existence of small architectural forms; presence of energy consumption control systems, and so on.

The principle of this approach (evaluation and classification of dwellings on set of consumer properties) is advisable to be extended to evaluation and classification of Compact Built-up Development Areas.

2 Problem Formulation

Compact Built-up Development Areas (which are intended for accommodation and vital human activities), in accordance with the system approach, can be presented in a system form, namely as a System Complex City Planning Formation (CPF) [2].

To do this we put forward the description of the system using research language of the theory of synthesis of complex systems, where CPF is presented in the form of a complex, multilevel hierarchal system. Wherein CPF is defined as a set of inter-related components (architectural and constructional component, engineering and network component, engineering and transport component, and territorial and spatial component), functioning together in order to ensure the required favorable living conditions and social vital activities in the area of mass housing development.

The detailed structure of CPF is shown in Fig. 1.

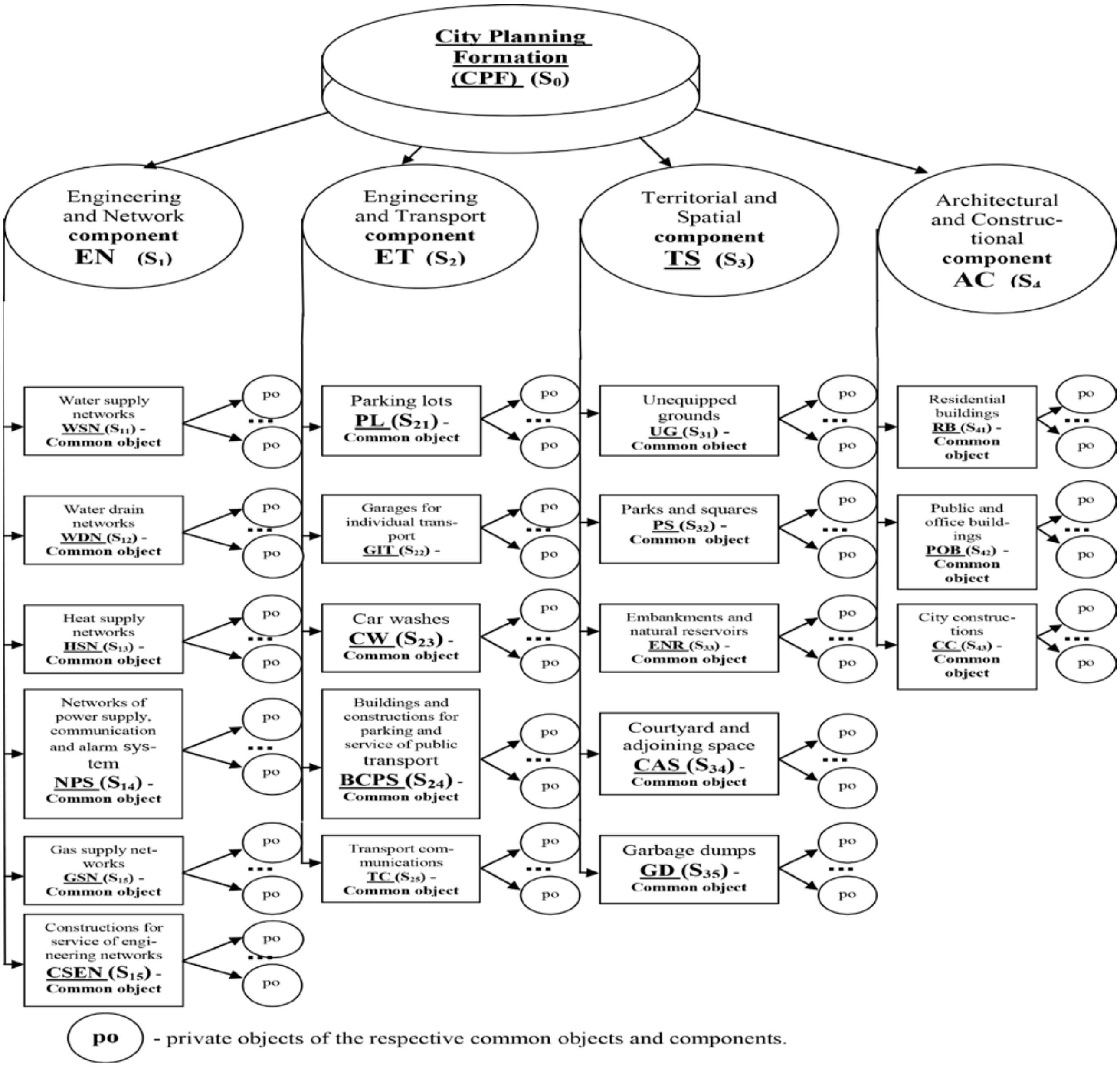


Fig.1. The objective structure of the city planning formation as a system including its components and objects.

The evaluation of CPF with the its following classification on set of consumer properties is appropriate to execute using the most general indicator that can qualitatively and quantitatively characterize CPF in the present situation and in the foreseeable future. It is suggested to apply the Indicator of Technical comfort (TC) as an indicator for characterization and evaluation of CPF itself and its components, general and private objects in correlation with the subject structure in Fig.1

Technical comfort of CPF is defined here as a comfort of technical construction of the social habitat environment, evaluated by the degree of conformity to the sanitary-hygienic norms, environmental safety rules and standards and other indicators, defined, if needed, by the qualified professional experts.

Introducing the notion of TC we suggest to define it by the objective components such as moral and physical depreciation (Fig. 2). Methodology of their definition is presented in the paper [2,3].

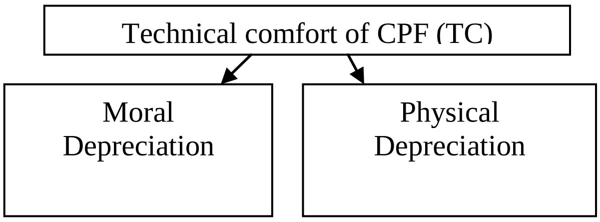
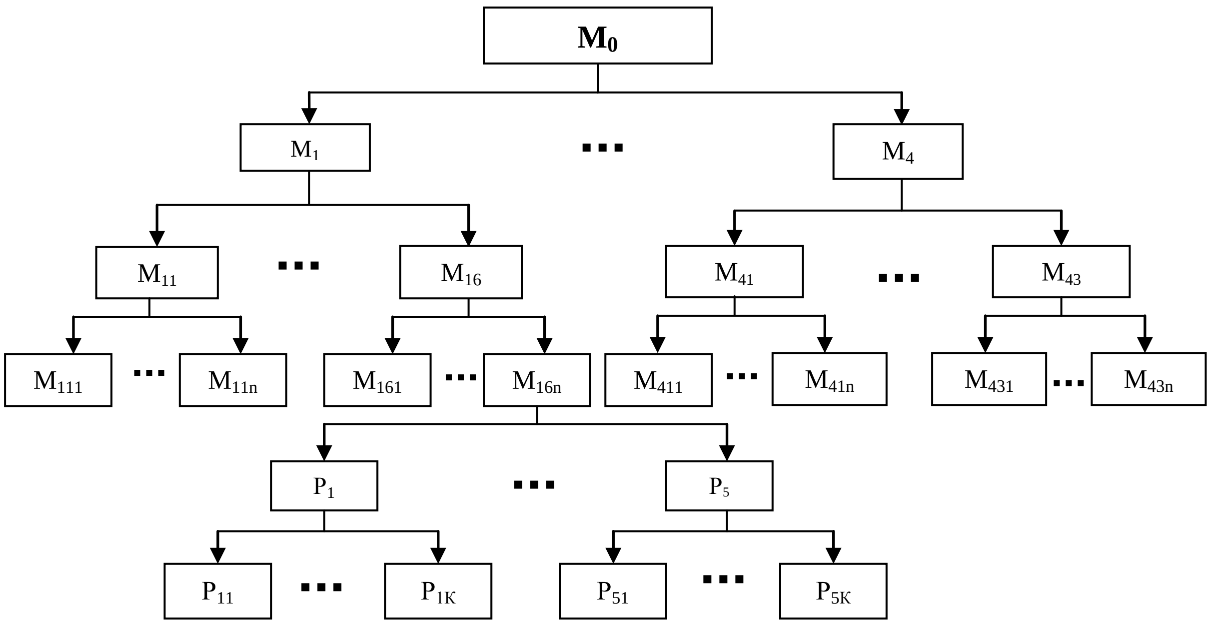


Fig.2. Technical comfort of CPF as a sum of moral and physical depreciation.

It is true that modern man (society) will feel most comfortable living in conditions of a certain city area - CPF (buildings, engineering equipment, transport infrastructure, etc.), built in compliance with modern ecological, operational, architectural and other requirements, in other words by the minimal moral depreciation, as well as by the condition of reliability, integrity and security of all components of CPF (buildings, engineering equipment, transport infrastructure, etc.), i.e. by the absence of physical dilapidation.

According to the subject structure (Fig.1), with the use of theory of multilevel hierarchal systems, indicators of physical and moral depreciation of all CPF are presented as a set of indicators of physical and moral depreciation of all its components. Similarly, indicators of physical and moral depreciation components are presented as a set of indicators of physical and moral depreciation of all objects included, and indicators of physical and moral depreciation of all general objects as a set - of physical and moral depreciation of its constituent private objects.

Based on above-mentioned, the indicator tree of moral depreciation of CPF presented in the form shown in Fig. 3. and physical depreciation presented in the form shown in Fig. 4.

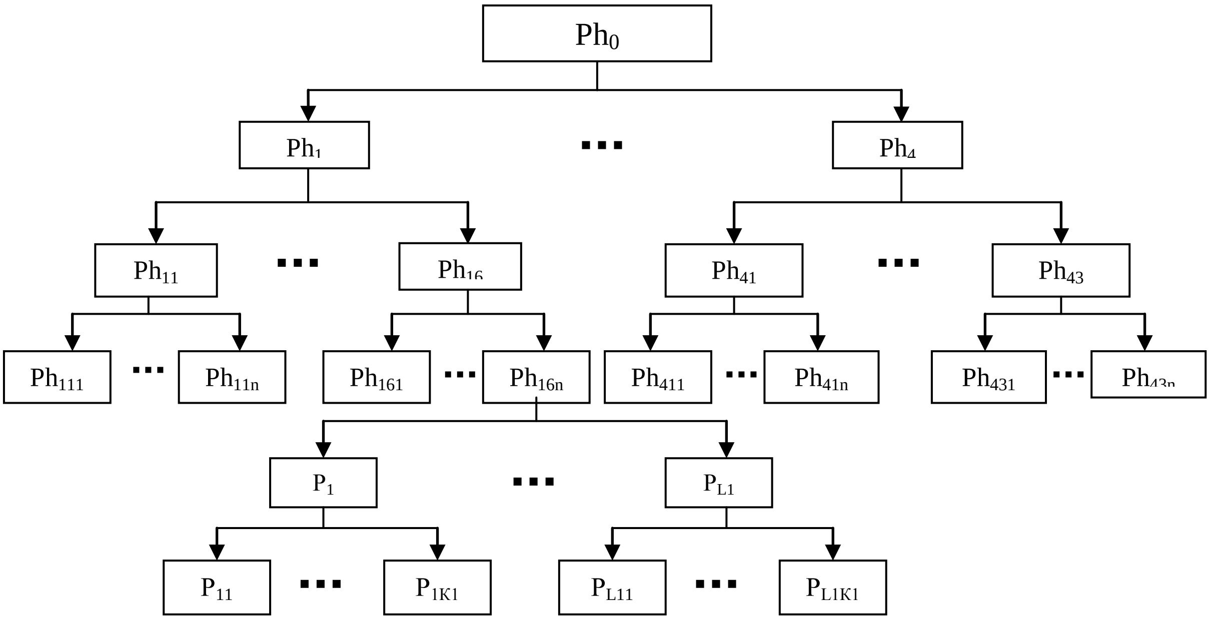


P_i, i = $\overline{1,5}$ - general indicators of moral depreciation of specific objects;

$P_{iк}$, i = $\overline{1,5}$, к = $\overline{1,к1}$ - specific indicators of moral depreciation of specific objects;

M – integral indicators of moral depreciation of CPF, its components, general and specific objects

Fig. 3. CPF moral depreciation indicator tree.



P_l, $l = \overline{1,L1}$ - indicators of physical depreciation of the constructions or elements of specific objects;

$P_{lк}$, $l = \overline{1,L1}$, $к = \overline{1,K1}$ - indicators of physical depreciation of separate parts of the constructions or elements of specific objects;

Ph – integral indicators of physical depreciation of CPF, its components, general and specific objects.

Fig. 4. CPF physical depreciation indicator tree.

By viewing all the territory of Compact Built-up Development Areas as a set of CPF, one can define different groups of CPF in the city structure, some of which can be characterized by the values of TC located in certain variation ranges. Further down we will call such groups classes. For example, city structure can have a group of CPF with the value of TC in the range from 20 до 40%, i.e. with the low comfort equal 2 points, which is highlighting the need of reconstruction of that kind of CPF.

Based on the analysis of values TC indicator of CPF classes, its components, general and private objects experts can make decisions about further operation or reconstruction of the given classes CPF and its components.

Thereby, we are facing a task of classification of mass housing development areas as CPF for making decisions about their maintenance and reconstruction.

3 Problem Solution

This task can be appropriately solved by implementation of the following systems of the following principles:

1. Method of extraction of CPF from the city development areas for the formation of different variants of CPF.

2. Method of defining the moral depreciation of CPF, its components, general and private objects.

3. Method of defining the physical depreciation of its components, general and private objects.

4. Method of defining the technical comfort of CPF, its components, general and private objects.

5. Method of grouping together various CPF into classes in compliance with concurrency of technical comfort value points.

6. Method of formation of system solutions for each class CPF for its further functioning, operation and reconstruction.

1. Method of CPF computation in Compact Built-up Development Areas for the formation of different variants of CPF. Method is be realized in the following order:

- preparing the input data by creating an inventory of the city development area in the form of electronic digital map, which will contain the detailed city planning (along with the detailed imaging) of urban groups and blocks, service institutions, engineering and communication networks, streets, roads, driveways, green zones, water basins , parking lots, etc.;

- defining a generating element of CPF – its main component. As a generating element of CPF we choose the general object – residential buildings (Fig.1). Our choice of residential building as a generating component is dictated by the fact that it takes into account the primary and most important urgent social need in the adequate dwelling.

- selecting all the generating elements or their sets on the electronic map with the requirement of having all components of CPF around them;

- contouring all the generating elements and their sets along with all components of CPF following the natural boarders, such as roads, forest belts, etc. thus receiving some *m*-variant of extraction, composed of the set in the of n units of CPF, where n = $\overline{1,N1_m}$.

2. Method of defining the moral depreciation of CPF, its components, general and private objects. Method is realized in the following order:

- selecting specific common indicators of the moral depreciation of private objects of CPF and definition of the integral indicators of moral depreciation of private objects included into total indicators of the moral depreciation.

- bundling the system of moral depreciation indicator from the subjacent level up to the next indicator on superincumbent level, based on the combination of the area of a single pie diagram with the Harrington scale [4].

Wherein values of subjacent level indicator of moral depreciation are included a single pie diagram in the form of square sectors. The value of the superincumbent level indicator of moral depreciation is defined as a sum of squares of these sectors.

Sectors have angles of opening proportional to the "scales" of correspondent subjacent level indicator of moral depreciation and radiuses reflecting values of these indexes in correlation with Harrington scale (Table 1).

More detailed method of defining of moral depreciation of CPF is presented in paper [3].

3. Method of defining the physical depreciation of its components, general and private objects. Method is realized in the following order:

- defining the values of indicators of physical depreciation of private objects based on the normative and expert methods;

- defining the values of indicators of physical depreciation of common objects , components of CPF and CPF itself, using expert method of defining their significances– «scales» along with the method of binding up (rolling up) values of indicators of physical depreciation of private objects into values of indicators of physical depreciation of general objects, and so on, by superposition (combination) of pie diagram with Huntington scale.

More detailed method of defining of physical depreciation of CPF is presented in paper [3].

4. Method of defining of values of indicators of TC of CPF, its components, general and private objects [2].

For the presentation of TC indicator in the qualitative form with corresponding linguistic and point characteristic it is advisable to use verbal-numeric scales, which include meaningfully described numerical values и name indicators and correspondent points and graduations. Wide spread in practice of such tasks solving received verbal-numeric Huntington scale [4]. A modified variant of scale for the CPF classification by TC is shown in Table 1. A certain point-graduation and correspondent linguistic definition is assigned to each value of indicator of technical comfort in the interval (0 – 100%).

Table 1. Huntington scale for the evaluation and classification of CPF by TK, its components, general and private objects

Verbal score	Point score	Numerical score
Very high – "excellent"	5	0,8 - 1
High – "good"	4	0,63 – 0,8
Average – "satisfactory"	3	0,37 – 0,63
Low – "bad"	2	0,2 – 0,37
Very low – "very bad"	1	0 – 0,2

5. Method of grouping of CPF in classes, in which calculated CPF have the same point (numeric) score. Method is realized in the following order:

- selecting of the next value of TC of calculated CPF;

- for the given values of TC selecting all CPF that have matching TC values.

- excluding the received CPF from the further consideration.

All above described actions conducted until all the values of the received indicators of TC are being examined. Formally, a multiplicity of numbers of CPF – G_n , included into the class with the equal *n* values of TC indicator can be presented as:

$$G_n = \{i / K_i = n, n \in \{n_p\},\ 1 \le P \le 5, i \in I\}, \quad (1)$$

where $I = \{i / i = \overline{1, I1}\}$ – a multiplicity of numbers of CPF; K_i – point value of TK indicator, i of CPF; $\{n_p\}$, $1 \le P \le 5$ – received values of TK indicator of the considered CPF.

6. Method of formation of system solutions for its further functioning, operation and reconstruction

for each class of CPF. Method is realized in the following order:

- analyses of values of TC indicators of CPF classes, its components, general and private objects;
- decision-making on the further operation or reconstruction of CPF classes.

In the most general form, the scheme of decision making on planning the renovation of the CPF, including its components and objects, is developed [2,3] and is shown in Fig 5.

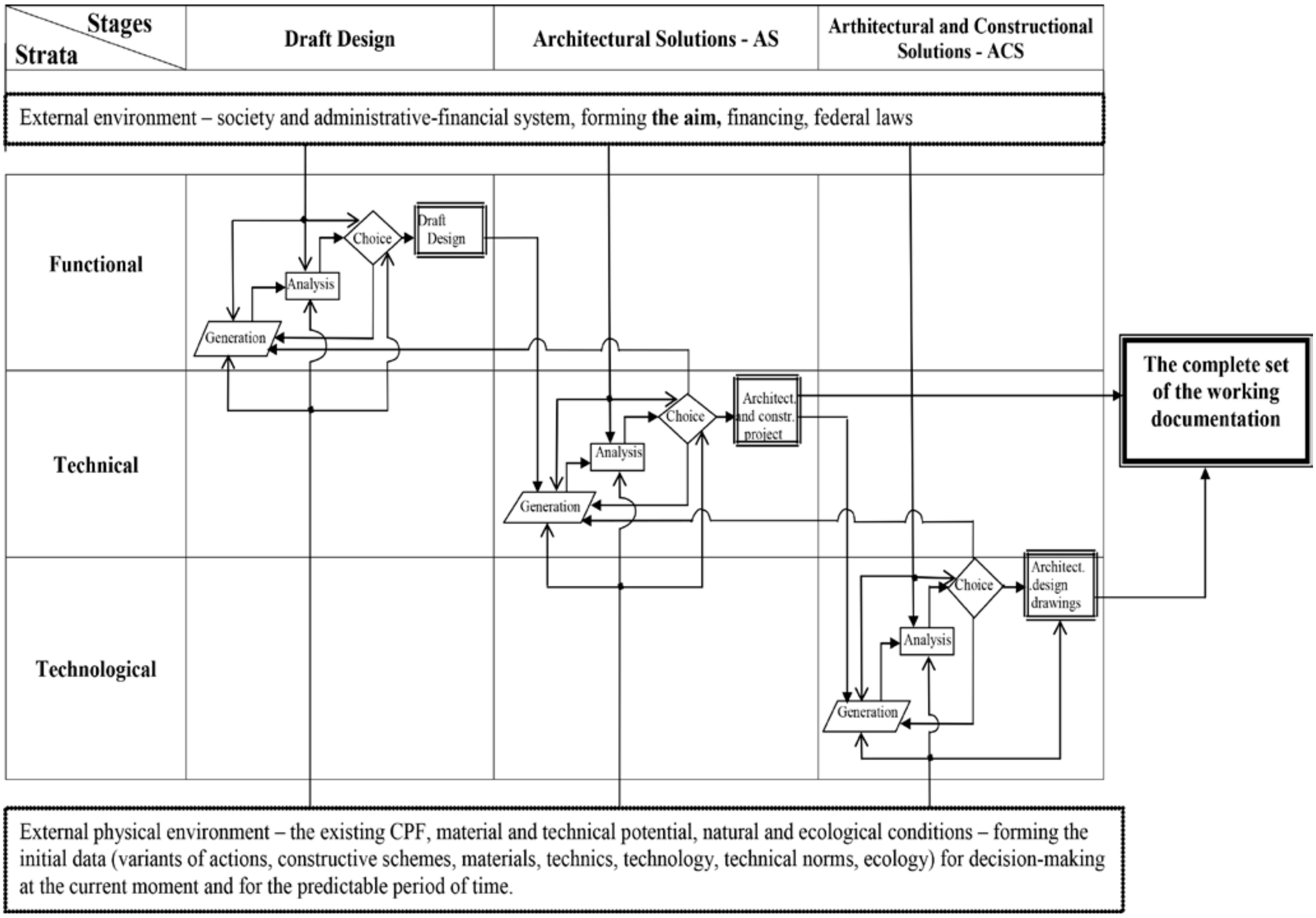


Fig 5. Technological scheme of decision-making on reorganization of compact built-up development areas

In papers [2,5] it is established that the main efficiency indicators of the CPF renovation are its TC and resource intensity (R). Resource intensity is characterized by such specific efficiency indicators as consumption of material and technical and also labor resources to achieve the desired TC.

In this case, the problem of synthesis of the CPF is to determine such solutions in the functional, technical and technological strata that provide the minimal expenses of R to achieve the desired TC.

To solve the problems of synthesis of complex systems of this type, multistage technological schemes of their solution are being developed nowadays [6].

Formally, the problem is written as follows:

Find $(R_1,R_2,R_3)_{\mathbf{opt}} = \text{arq} \min_{<R_1, R_2, R_3>} R(R_1,R_2,R_3)$

At the restrictions of $TC(R_1,R_2,R_3) \geq TC_{\mathbf{req}}$,

where R1 - is the set of admissible actions, R2 - is the set of admissible technical solutions, R3 - is the set of admissible technological solutions.

In the more detailed way the basis of methodology of decision-making for the reconstruction of CPF at the level of functional stratum is represented in [7].

It was found that the design of reconstruction of the whole CPF should begin with the development of the action variants for reconstruction of its constituent specific objects (SO).

The choice of an appropriate variant of decisions for making action on the functional stratum is made by selection of such decisions on the action for each of the SO, which provide a final estimation of the status of the whole CPF by technical comfort (TC) - "good" or "excellent" and minimize the total resource intensity for the implementation of these decisions [7].

Next, it is necessary to set the trend and features of decision-making on the sequence of implementation of the concrete SO of each of the considered actions with transfer to technical and technological strata.

On the basis of the main purpose of CPF, the main variants of actions are as follows: R_{11} - extraordinary repair (EO); R12 - capital repair (CR); R13 - reconstruction and modernization (RM); R14 - demolition and dismantling of the object (DD); R15 - demolition and dismantling of the old SO together with the construction of the new ones (DDN); R16 - extraordinary repair of the old SO together with the construction of the new additional SO (ERN); R17 - capital repair of the old SO together with the construction of the new and additional objects (CRN); R18 - reconstruction and modernization of the old SO together with the construction of the new and additional objects (RMN); R19 - construction of the new objects, additional to the given SO (CN).

To implement the actions such as "ER" and "CR" in relation to a particular SO, it is advisable, bypassing the technical stratum, immediately proceed to the technological stratum. This is due to the fact that in this case, technical solutions (TS), aimed at reducing the physical depreciation (PD) of the SO, for the vast majority of repair works in the housing and civil construction, are already included in the damage report made on the stage of the CPF inspection and in the sketch block diagram (SBD), developed on the functional stratum [7]. This increases the technical comfort (TC) of the given SO in accordance with the developed method of its estimation [2]. When selecting the actions of ER or CR, if necessary (in case of replacement and strengthening the supporting structures, or complex production conditions of work), TS are combined with working drawings of the repaired parts of buildings and constructions, and with technological schemes of work production developed on the technological stratum.

For implementation of the action "RM" we switch to the technical stratum and apply TS specifying the SBD of the SO which is being reconstructed or modernized [7]. This sets how PD and MD of the given SO are reduced, i.e. TC is increased to the required value - according to the known technique [2,7]. Then, for the implementation of TS we switch to the technological stratum.

For implementation of the action "DD" in relation to a particular SO it is reasonable to proceed directly to the technological stratum, bypassing the technical stratum, as the TS for demolition or dismantling of SO are already included in the SBD developed on the functional stratum. This reduces MD of the general object (GO) - in accordance with [2, 3], and increases its TC. Where necessary, during dismantling of complex structures and in difficult conditions, TS are combined with technological schemes of work production, developed on the technological stratum.

For implementation of the action "DDN" it is necessary:

- On the one hand - at the demolition and dismantling of the given SO to switch to the technological stratum, while maintaining the same sequence as at the implementation of the action DD;

- On the other hand, switching to the technical stratum, to apply TS specifying the SBD of the newly constructed SO, and then - to the technological stratum. This provides a reduction of MD of the general object [3] with an increase of its TC [2]

For implementation of the actions "ERN" and "CRN" it is necessary:

- At the extraordinary and capital repair of the given SO to switch to the technological stratum, while maintaining the same sequence as at the implementation of the actions ER and the CR;

- Switching to the technical stratum, to apply TS specifying the SBD of the newly constructed SO, and then - to the technological stratum.

This provides a reduction of MD of the given SO with an increase of its TC, as well as a reduction of MD of the general object, which altogether increases TC of the general object.

For the implementation of the action "RMN", switching to the technical stratum, we apply TS specifying the SBD of the SO which is being reconstructed or modernized, and also TS specifying the SBD of the newly constructed SO. This reduces the PD and MD of the given SO as well as PD and MD of the general object, which altogether provides a significant increase in TC of the general object. Then, for the implementation of TS we switch to the technological stratum.

For implementation of the action "CN" on the technical stratum we apply TS specifying the SBD of the newly constructed SO, which altogether reduces MD of the general object and, accordingly, increases its TC. Then, for the implementation of TS we switch to the technological stratum.

The general flowchart showing the sequence of development of the project - technical and technological solutions for the reconstruction and modernization of compact built-up development areas is represented in the Fig. 5.

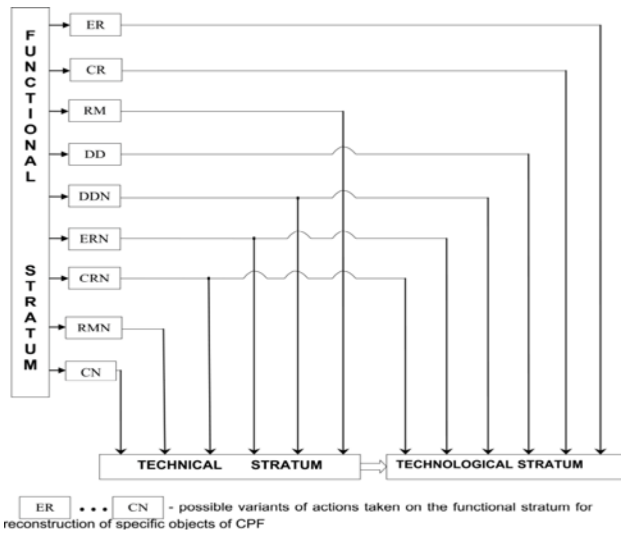


Fig. 5. Flowchart of the sequence of developing the project solutions for the implementation of possible actions for reconstruction of specific objects of CPF.

Let us take a look at the characteristics of the development of possible solutions for implementation of the actions set out in the functional stratum - CR and ER, with the switch directly to the technological stratum. These actions are aimed at the elimination or significant reduction of PD of the separate SO and perhaps partly at reducing moral depreciation MD of the SO, respectively, with an increase in its TC.

It is reasonable to start the projecting and implementation of the actions ER and CR with partitioning the considered SO into separate structural parts and engineering systems.

As an example we will take the SO - residential building, representing it as a set of interacting elements in accordance with the recommendations [8]. Analyzing the methods of implementing repair and construction works [8] it was stated that for a separate construction element, a type of engineering equipment of a residential building (water supply, heating, electricity, etc.) or their separate sections, the following technological variants of implementing the actions EO or CR are possible:

- Minor repairs by filling of dents, cracks, etc. (MR);
- Reinforcement and consolidation of individual sections (RE);
- Partial replacement of worn-out parts of structures or engineering systems (PR);
- Complete replacement of a structural element, coating, detail, or item (CR).

Generation and analysis of competitive variants of ER and CR depends on the existing PD and MD of structural parts of the building and (or) its engineering systems and is defined by a set of both conventional and new methods of implementation of technological variants of MR, RE, PR, CR, which in their turn depend on the construction materials, details, equipment, tools, etc. used during the repair.

An example of generation of variants for the implementation of actions ER and CR is represented in a form of a tree in Fig. 6. There are also highlighted rational action variants of ER or CR selected as a result of the analysis. The selection is made by minimizing the resource intensity (R) for a particular method of implementing the considered technological variant of repair by estimating the corresponding financial cost.

Let us take a (K) - constructive element or element of engineering infrastructure of a residential building and a scheme of variants for its repair in the form of a tree graph – Fig. 7. With each leaf $i=\overline{1,4}$, $n=\overline{1,N}$, $m=\overline{1,M}$ we associate the resource intensity indicator $R_{\mathbf{kinm}}$, the physical depreciation indicator $PD_{\mathbf{kinm}}$ and the moral depreciation indicator $MD_{\mathbf{kinm}}$. Then, formally, for each **k**, $k=\overline{1,K}$, the problem of finding the rational variant of implementing the action ER or CR can be written as follows:

Find

$$< i, n, m> opt = \underset{<i,\, n,\, m>}{\text{arq min}}\ R_{\mathbf{kinm}}$$

at the restrictions:

$PD_k \leq PD0_k$,

$MD_k \leq MD0_k$,

$i=\overline{1,4}$, $n=\overline{1,N}$, $m=\overline{1,M}$

Here $PD0_k$, $MD0_k$ – are the required minimally possible indicators of physical and moral depreciation K, defined in accordance with the normative values.

This problem is solved by the method of exhaustive search of variants over the indicators "<i, n, m>".

As a result, we define the tree leaf corresponding to the minimal value of the indicator R_k. It is easy to see that the movement from the leaf up to the root will set a rational variant of actions ER or CR.

Thus formed a number of technological solutions for the repair of corresponding structures and engineering systems of a residential building is reasonable to take as a basis for development of the final project of repair work organization.

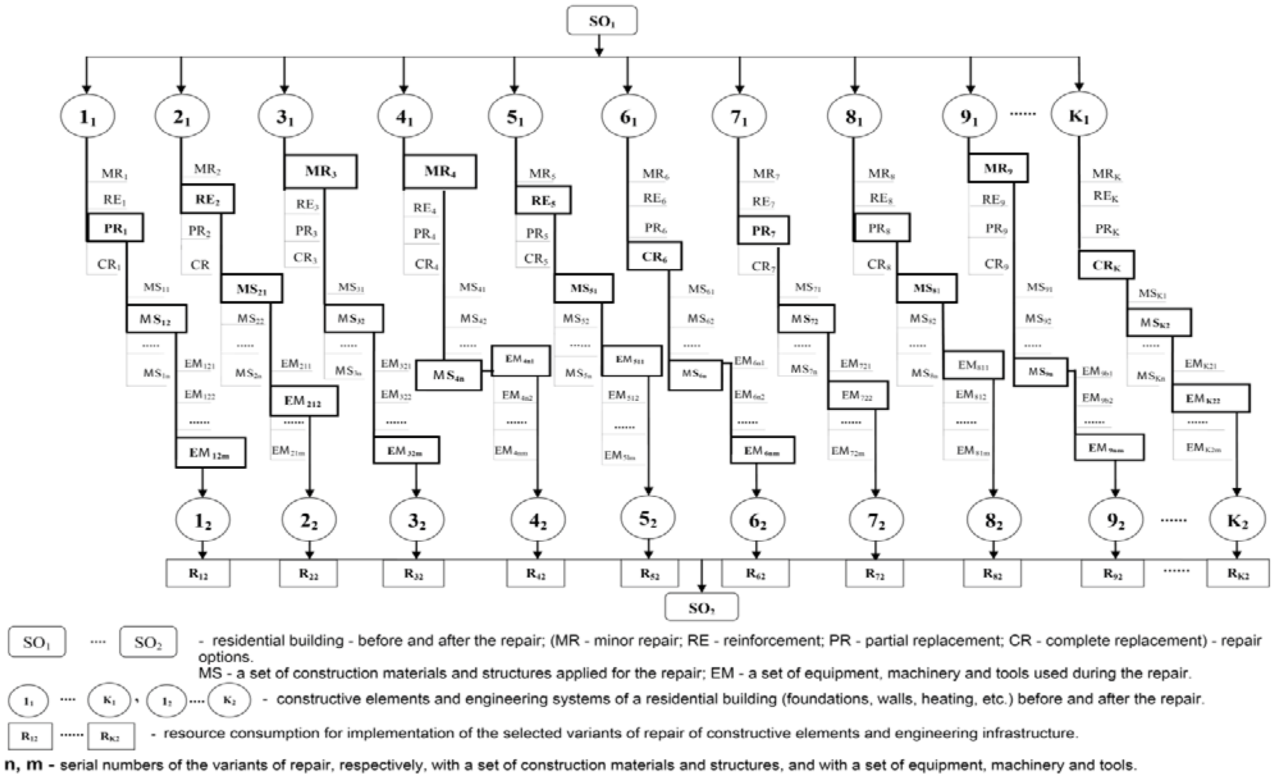


Fig. 6. The scheme of variants of the production technology works at the implementation of actions ER and CR for repairing the structural elements and engineering infrastructure of a residential building and a set of rational technological variants of repair.

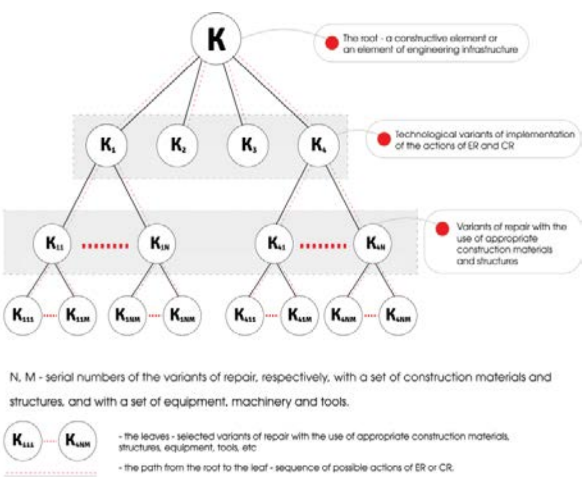


Fig. 7. Constructive element or element of engineering infrastructure of a residential building and a multitude of variants for its repair in a form of the tree graph.

4 Conclusion

1. Technical Comfort has been proposed as an objective indicator of estimation of consumer properties of CPF, which is qualitatively and quantitatively characterize the condition of CPF and its components for the current present and foreseeable future, defined by the set of moral and physical depreciation of CPF itself and its components.

2. The method of CPF grouping in classes has been developed based on Technical Comfort value points coinciding.

3. The methodological approach to establishing the sequence of development of the project technical and technological solutions on the reconstruction and modernization of compact built-up development areas is developed.

4. An example of generation of variants of technological solutions for the implementation of such actions as "extraordinary repair" and "capital repair" is given.

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