Enhanced technology of quantitative assessment for technological suitability of real estate for technical improvements

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Abstract. The key problems of organizing a rational investment in technical improvements (repair and reconstruction) of buildings and structures, as a way to improve the real estate functional efficiency are the quantitative ranking problems of objects to be improved according to the actual resource needs of work, the resulting economic assessment and reconstruction social effect, technical feasibility integrated assessment and work conditions. Particularly up to date is the question of quantifying the conditions for making improvements when implementing investment programs financed by budgetary funds, under which, as a rule, complex territorial improvement is carried out, or targeted programs are being implemented to improve the municipal real estate for functional purposes. To contribute to the effective solution of these problems and to be an effective tool for the established practice of managing urban real estate background, the methodological approaches presented in the work and the algorithms for constructing a quantitative assessment of the technological suitability of real estate for functional improvement are presented. The paper demonstrated the proposed methodologies practical use examples, evaluating the potential effectiveness of the property manager’s activities, proposed tools for the practical implementation of the techniques in industry software.

Introduction
Reconstruction of buildings and structures is one of the progressive areas of construction, since as a result, the functionality is improved, the technology is modernized, architectural, social, town-planning tasks are solved [1]. Reconstruction, obviously, has a huge economic effect, since based on the buildings existing elements, which reduces the overall resource work intensity. At the same time, when reconstructing in comparison with new construction, there are more complex tasks: erecting the construction site in conditions of constraint, without stopping the current process, to carry out repair and replacement works of worn out structural elements. In general, reconstruction is the most efficient and effective way of not only extending the period of safe operation, but also improving the real estate object operation quality, expressed in updating and improving a number of its consumer characteristics, collectively referred to as technical improvements.

The most important condition for economic efficiency and technological feasibility of real estate reconstruction is the feasibility study of the work scope and the organizational and technological reconstruction plan established at the stage of strategic planning, operational management or budgeting for operation and maintenance of real estate, especially on the balance of federal or municipal budgets.
The authors created a high-tech production “The new methods and tools development for property management in the public sector and implement them in the software package of the information-analytical system for centralized management of property owned by constituent entities of the Russian Federation, municipalities, as well as the property of state-owned companies within the framework of work on a comprehensive project” which offers a comprehensive methodology for quantifying organizational and technological the suitability of real estate for the proposed technical improvements, which has a high potential for formalization and integration into the property management digital environment, and at the same time, analytical information presentation exceptional visibility, simplicity of its interpretation and low resource intensity of primary deployment and administration in the current practice of property managers of organizations.

For the real estate technological suitability analysis, such properties of structural elements of buildings, TS, as flexibility (the ability to dismantle the element without loss of the building structural reliability), manufacturability (technical problems associated with dismantling and replacing the element), innovativeness (the possibility of using replacement innovative materials and technology) are used and Technosphere safety (the ability to safely assemble / disassemble the structure). Comparative assessment of TS is carried out by quantitative specific weights of the indicators $k_i$, determined by the compared indicators ranking according to the Fishburn rule (Table 1). The buildings constructive properties nomenclature expansion is necessary to be taken into account the regional specifics of real estate or the sectoral nature of management activity. It is carried out in the same way without changing the general evaluation algorithm.

**Table 1.** Ranking indicators of the real estate technological suitability for reconstruction

| TS indicator  | Grade | Specific gravity, $k_i$ |
|---------------|-------|------------------------|
| TS1. Flexibility | 4     | $4/10=0.4$            |
| TS2. Manufacturability | 3    | $3/10=0.3$            |
| TS3. Innovativeness | 2    | $2/10=0.2$            |
| TS4. Technosphere safety | 1    | $1/10=0.1$            |
| Total         | 10    | 1                      |

To provide a comparative assessment of technological suitability for the reconstruction of buildings with a wide range of design solutions, individual structural elements was ranking performed according to four indicators TS, estimated on a three-point scale from 1 (the quality of the property is unacceptable, the property is not recoverable) to 3 fully recoverable), taking into account their weights (Table 1).

$$TS_{av} = TS_i k_i.$$  

Technological suitability ratings tabulation for individual classification groups of structural and engineering elements most commonly used for budget-financed buildings in the Russian Federation is presented in Table 2.

**Table 2.** The main buildings technical solutions and the elements for reconstruction and repair suitability degree

| Constructive solution of the building | Structural and engineering elements of the building | TS1 | TS2 | TS3 | TS4 | TS_{av} |
|--------------------------------------|------------------------------------------------|-----|-----|-----|-----|---------|
| Frame-panel building                 | Vertical supporting structures - columns, stiffening diaphragms | 1   | 1   | 1   | 1   | 1       |
|                                     | Horizontal supporting structures - floor slabs, monolithic reinforced concrete plots | 2   | 1   | 3   | 2   | 1.9     |
The technological suitability evaluation of the specific analyzed buildings for reconstruction, ETSi, is carried out on the basis of decomposition of the object’s design solution into separately assessed structural elements attributable to tabulated (Table 2), identifying and evaluating physical wear of elements, Fi, according to the methods [2] and subsequent averaging according to them, element-wise ratings of technological suitability of TS_{av}. The results of the individual public buildings ETS in 2019 that are on the balance of the municipality of Belgorod in 2019 are presented in Table. 3

| Constructive solution of the building | Structural and engineering elements of the building | TS_1 | TS_2 | TS_3 | TS_4 | TS_{av} |
|--------------------------------------|----------------------------------------------------|------|------|------|------|--------|
| Enclosing structures - wall reinforced concrete panels | 2   | 3   | 3   | 2   | 2.5 |
| Partitions - light concrete masonry materials | 3   | 1   | 3   | 3   | 2.4 |
| Engineering networks - typical solutions of the 60s. 70s | 2   | 2   | 2   | 3   | 2.1 |
| **Total** | | | | | **9.9** |
| Supporting structures vertical - stone walls | 1   | 1   | 1   | 1   | 1.0 |
| Horizontal supporting structures - prefabricated floor slabs | 2   | 1   | 3   | 3   | 2.0 |
| Enclosing structures - stone walls with multilayer insulation | 1   | 2   | 2   | 2   | 1.6 |
| Partitions - light concrete masonry materials | 3   | 3   | 3   | 3   | 3.0 |
| Engineering networks - typical solutions of the 50s - 80s | 2   | 2   | 2   | 3   | 2.1 |
| **Total** | | | | | **9.7** |
| Vertical supporting structures - columns | 1   | 1   | 1   | 1   | 1.0 |
| Horizontal supporting structures - crossbars. truss | 2   | 1   | 2   | 2   | 1.7 |
| Fencing - sandwich panels | 1   | 2   | 2   | 2   | 1.6 |
| Partitions - light concrete masonry materials | 3   | 2   | 2   | 2   | 2.4 |
| Engineering networks - typical solutions of the 60s - 80s | 2   | 2   | 2   | 3   | 2.1 |
| **Total** | | | | | **8.8** |
| Vertical supporting structures - stone walls. internal frame | 1   | 1   | 1   | 1   | 1.0 |
| Horizontal supporting structures - crossbars. reinforced concrete floor slab | 1   | 1   | 2   | 1   | 1.2 |
| Enclosing structures - stone walls | 1   | 1   | 2   | 1   | 1.2 |
| Partitions - light concrete masonry materials | 3   | 2   | 2   | 2   | 2.4 |
| Engineering networks - typical solutions of the 70s - 90s | 2   | 2   | 2   | 3   | 2.1 |
| **Total** | | | | | **7.9** |
Table 3. The technological suitability actual integral assessment for the reconstruction of individual public buildings that are on the balance of the municipality of Belgorod in 2019

| Estimated building | Constructive solution of building elements                                      | F_i  | TS_i,av | ETS_i |
|--------------------|--------------------------------------------------------------------------------|------|---------|-------|
| Building №1        | Vertical supporting structures - columns. stiffening diaphragms                 | 30%  | 1       | 0.30  |
|                    | Horizontal supporting structures - floor slabs. monolithic reinforced concrete plots | 40%  | 1.9     | 0.76  |
|                    | Enclosing structures - wall reinforced concrete panels                          | 20%  | 2.5     | 0.50  |
|                    | Partitions - light concrete masonry materials                                  | 25%  | 2.4     | 0.60  |
|                    | Engineering networks - typical solutions of the 60s. 70s                      | 35%  | 2.1     | 0.74  |
| The object ETS     | Supporting structures vertical - stone walls                                   | 35%  | 1       | 0.35  |
| Building №2        | Horizontal supporting structures - prefabricated floor slabs                  | 35%  | 2       | 0.70  |
|                    | Enclosing structures - stone walls with multilayer insulation                 | 50%  | 1.6     | 0.80  |
|                    | Partitions - light concrete masonry materials                                  | 30%  | 3       | 0.90  |
|                    | Engineering networks - typical solutions of the 50s - 60s                    | 35%  | 2.1     | 0.74  |
| The object ETS     | Bearing structures vertical - stone walls. racks. brick pillars              | 20%  | 1       | 0.20  |
| Building №3        | Horizontal supporting structures - beams. reinforced concrete slab            | 25%  | 1.2     | 0.30  |
|                    | Enclosing structures - stone walls                                            | 27%  | 1.2     | 0.32  |
|                    | Partitions - light concrete masonry materials                                  | 20%  | 2.4     | 0.48  |
|                    | Engineering networks - typical solutions of the 80s - 90s                    | 30%  | 2.1     | 0.63  |
| The object ETS     | Supporting structures vertical - stone walls                                   | 35%  | 1       | 0.35  |
| Building №4        | Horizontal supporting structures - prefabricated floor slabs                  | 45%  | 2       | 0.9    |
|                    | Enclosing structures - stone walls with multilayer insulation                 | 40%  | 1.6     | 0.64  |
|                    | Partitions - light concrete masonry materials                                  | 40%  | 3       | 1.2    |
|                    | Engineering networks - typical solutions of the 50s - 60s                    | 40%  | 2.1     | 0.84  |
| The object ETS     |                                                                                     |      |         | 3.93  |

For the qualitative categorization of the boundaries and the volatility of the technological suitability estimates obtained in a practical analysis of real buildings, the spectral filtering by marking marginal objects (the technological suitability of which is empirically rated most and least highly) is proposed for use. The actual boundaries of the ETS from 1.93 to 3.93, obtained in the example tableb3, allow to establish the following categories of technological suitability:

- technological suitability category
  - suitable
  - ETS
  - 3.6 and up
unsuitable 2.3 ... 3.5
unsuitable 2.2 or less

The repair and restoration potential assessment associated with establishing the actual physical deterioration of the structures and engineering networks of the facilities is updated for a certain period of time (the recommended assessment interval is two years), during which the amount of physical deterioration of the building $F_i$ will change after the repair and restoration measures allocated funding in accordance with the repair and restoration potential assessment results in the previous year [3-5].

Periodically updated, dynamic ETS of buildings and structures allows for effective strategic and operational planning of the budget, directed to the buildings repair by the activities effectiveness quantitative indicators monitoring carried out. So, for example, the planned effect from the production of the reconstruction financed by the municipal budget presented in Table. 3 buildings in 2019-2020 will be expressed in the following change in physical wear by structural elements groups of (Table 4) and ETS buildings (Table 4).

**Table 4.** The predicted change in physical deterioration of structural elements during the repair and restoration of the building

| Object   | Construction elements | Vertical supporting structures | Horizontal supporting structures | Walling | Partition | Network engineering |
|----------|------------------------|--------------------------------|---------------------------------|---------|-----------|---------------------|
|          |                        | 2019 | 2021 | 2019 | 2021 | 2019 | 2021 | 2019 | 2021 | 2019 | 2021 |
| Building No1 | Vertical supporting structures | 30%  | 10%  | 40%  | 20%  | 20%  | 5%   | 25%  | 5%   | 35%  | 15%  |
| Building No2 | Vertical supporting structures | 35%  | 11%  | 35%  | 11%  | 50%  | 26%  | 30%  | 6%   | 35%  | 11%  |
| Building No3 | Vertical supporting structures | 20%  | 3%   | 25%  | 8%   | 27%  | 10%  | 20%  | 3%   | 30%  | 13%  |
| Building No4 | Vertical supporting structures | 35%  | 14%  | 45%  | 24%  | 40%  | 19%  | 40%  | 19%  | 40%  | 19%  |

**Table 5.** Predicted integral assessment of technological suitability for the reconstruction of individual public buildings that are on the balance of the Belgorod municipality in 2021

| Estimated building | Constructive solution of building elements | $F_i$ | $TS_{av}$ | ETS$_i$ |
|--------------------|-------------------------------------------|-------|-----------|---------|
| Building No1       | Vertical supporting structures - columns, stiffening diaphragms | 10%   | 1         | 0.90    |
|                    | Horizontal supporting structures - floor slabs, monolithic reinforced concrete plots | 20%   | 1.9       | 1.51    |
|                    | Enclosing structures - wall reinforced concrete panels | 0%    | 2.5       | 2.49    |
|                    | Partitions - light concrete masonry materials | 5%    | 2.4       | 2.27    |
|                    | Engineering networks - typical solutions of the 60s, 70s | 15%   | 2.1       | 1.78    |
| The object ETS     |                                           |       |           | **8.94**|

| Building No2 | Supporting structures vertical - stone walls | 11%   | 1         | 0.89    |
|              | Horizontal supporting structures - prefabricated floor slabs | 11%   | 2         | 1.78    |
|              | Enclosing structures - stone walls with multilayer insulation | 26%   | 1.6       | 1.19    |
| Estimated building | Constructive solution of building elements | $F_i$ | $TS_{av}$ | $ETS_i$ |
|--------------------|--------------------------------------------|-------|-----------|---------|
|                    | Partitions - light concrete masonry materials | 6%    | 3         | 2.82    |
|                    | Engineering networks - typical solutions of the 50s - 60s | 11%   | 2.1       | 1.87    |
| **The object ETS** | **8.55**                                  |       |           |         |
| **Building №3**     | Bearing structures vertical - stone walls, racks, brick pillars | 3%    | 1         | 0.97    |
|                     | Horizontal supporting structures - beams, reinforced concrete slab | 8%    | 1.2       | 1.10    |
|                     | Enclosing structures - stone walls            | 10%   | 1.2       | 1.08    |
|                     | Partitions - light concrete masonry materials | 3%    | 2.4       | 2.32    |
|                     | Engineering networks - typical solutions of the 80s - 90s | 13%   | 2.1       | 1.82    |
| **The object ETS** | **7.28**                                  |       |           |         |
| **Building №4**     | Supporting structures vertical - stone walls | 14%   | 1         | 0.86    |
|                     | Horizontal supporting structures - prefabricated floor slabs | 24%   | 2         | 1.51    |
|                     | Enclosing structures - stone walls with multilayer insulation | 19%   | 1.6       | 1.29    |
|                     | Partitions - light concrete masonry materials, gypsum concrete slabs, cinder slabs | 19%   | 3         | 2.42    |
|                     | Engineering networks - typical solutions of the 50s - 60s | 19%   | 2.1       | 1.69    |
| **The object ETS** | **7.78**                                  |       |           |         |

Empirically assigning marginal objects, according to the actual $ETS$ borders from 7.28 to 8.94, obtained in the example table, 4, it will be possible to establish the following categories of technological suitability:

- **technological suitability category**                  | **ETS**
- suitable                                              | 8.9 and above
- unsuitable                                            | 7.3 ... 8.8
- unsuitable                                            | 7.2 or less

The presented immovable objects quantitative ranking technique according to technological suitability for the proposed technical improvements created by reconstruction and repair makes it possible to enrich analyst’s tools in the field of building management and operation with an effective tool for rational budgeting of municipal and federal real estate possessing the required modern digital economy of breadth and flexibility of formalization, visibility interpretation of results and the possibility minimally resource-intensive integration into the existing practice of property management for various purposes and industry sector.

**References**

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