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MODEL AND CRITERIA FOR JUSTIFYING REPAIR COSTS FOR RESIDENTIAL BUILDINGS

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Abstract: This article is devoted to the economic, technical, and organizational justification of repair expenditures (current and capital) during the operation of residential buildings. Relying on the specific features of repair and construction production, as well as on experimental, theoretical, and practical studies, the research proposes an integrated methodological–systemic approach that supports decision-making at the operation stage. The aim of the system is to ensure quality that meets regulatory requirements and safety indicators while minimizing resource consumption and simultaneously reducing the life-cycle cost (LCC) of the building over its service life.

Keywords: operation, residential, construction, cost assessment, reconstruction, housing stock, estimate.

INTRODUCTION

In recent years, intensive methods—repairing and reconstructing residential buildings—have increasingly replaced extensive approaches to renewing the housing stock. The main reason is that the one-time expenditures required for continued operation are lower than those for new construction. In addition, in many megacities there is virtually no vacant land left for housing and civil construction. The architectural and historical value of many cities in Uzbekistan likewise requires both preserving these areas and implementing a set of measures to reorganize urban planning, step by step adapting it to modern requirements.

Pursuant to Resolution No. 577 of the Cabinet of Ministers of the Republic of Uzbekistan dated 6 October 2022, "On measures to simplify requirements in the field of construction and to systematize regulatory documents in the field of technical regulation," the main objectives of simplifying construction requirements are not accidental. They include: systematizing urban planning norms and rules to eliminate excessive bureaucratic procedures in construction; reviewing outdated urban planning norms and rules and aligning them with current reforms; improving them by analyzing problems related to practical application; and harmonizing urban planning norms and rules with international normative and technical documents on construction [1].

However, in the absence of a unified, scientifically grounded approach to planning, designing, and carrying out reconstruction, work is being conducted in an unsystematic manner. As a result, discrepancies are arising between the reconstruction volumes that are needed and those actually being performed.

Results. There is a substantial body of fundamental research devoted to organizational and technological preparation for new construction and its key element—organizational and technological design. The attention given to this area of construction science is explained by the conclusion that the effectiveness of managing large-scale construction is largely determined by the preparation system, which in turn must be based on a systems approach to solving the complex of construction problems.

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The current level of scientific and technological development in society, on the one hand, imposes generally higher new requirements on construction production and, on the other hand, opens up new opportunities for its improvement and renewal. Under these conditions, the rational use of resources (energy, materials, labor, and finance)—including opportunities for saving them—must be resolved at a new conceptual level, using the example of construction and installation works in the processes of erecting, operating, reconstructing, and demolishing multi-story residential buildings [2].

Reconstruction of buildings has several distinctive features that significantly differentiate it from new construction: preserving non-replaceable structural components (walls, foundations); carrying out work within an established urban environment; and performing special technological processes such as dismantling structures, elements, and systems, and strengthening structures to be retained. According to available data, 69 percent of the country's multi-story housing stock (i.e., 30,000 buildings) was built before 1991, of which nearly 10,000 housing units have been identified as in need of repair [3].

Therefore, approaches to justifying costs in organizational and technological preparation and organizational and technological design during building reconstruction must be renewed. Yet, to date, a robust scientific-methodological and regulatory base that would allow for calculating and justifying rational expenditures during reconstruction has scarcely been formed.

At present, in global construction practice, the ratio between precast and cast-in-place concrete buildings and structures is trending in favor of cast-in-place. For example, in the United States they account for 37 and 63 percent respectively; in the United Kingdom, 32 and 68 percent; and in France, 14 and 86 percent [4].

Based on this, the task of justifying repair costs during the operation of residential buildings and developing methods for evaluating and selecting cost-optimal solutions is urgent. The factors cited above also determined the objective of choosing this line of research.

The studies conducted and their implementation in operational practice make it possible to draw the following analytical conclusions:

First, determine and classify the cost structure. For residential buildings, systematize the composition of repair costs during the operational period (planned preventive maintenance, emergency restoration, capital repair, modernization), the drivers of their formation, and their interactions. It should be taken into account that structural solutions, engineering systems, climatic conditions, and intensity of use significantly affect the cost profile.

Second, apply budgeting and calendar-scheduling methodology. This envisages developing a method of distributing work volumes based on non-rhythmic flows, coordinating repair works with the operational schedule while considering "peak" loads and seasonal constraints. This approach must account for residents' interests (comfort and safety), the need for temporary relocations, entrance/egress congestion, and temporary rerouting of utility networks.

Third, incorporate criteria for evaluating economic efficiency. A multi-criteria evaluation system can be proposed to compare repair scenarios: discounted costs (NPV), life-cycle cost (LCC), unit (per-square-meter) cost, service level (SLA), and reliability indicators (failure frequency, mean time between failures). For each indicator, zones of reasonable applicability should be defined, and suitability (fitness) functions that express the balance among indicators should be proposed.

Fourth, apply optimality criteria and selection algorithms. Two principal optimality criteria should be substantiated for repair solutions:

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minimizing downtime over the operational cycle (a differential criterion);

minimizing total unit costs (per m² and/or per year).

Mathematical models and optimization methods (constrained optimization, sensitivity analysis) should be developed to select scenarios according to these criteria and to determine combinations of preventive, corrective, and condition-based maintenance (CBM) strategies.

Fifth, manage risks and uncertainties. Scenario analysis and Monte Carlo simulations [5] should be applied for uncertainties related to price fluctuations, disruptions in material supplies, accident probabilities, and updates to regulatory requirements. As a result, a risk-adjusted contingency budget and an algorithm for resequencing work can be proposed.

Sixth, enable data-driven decision-making. Based on the building's digital passport (logbook), technical inspection protocols, and sensor monitoring (vibration, moisture, temperature), condition indicators are formed. Using these, repair priorities, "critical nodes," and transition thresholds (triggers) to capital repair should be determined.

Seventh, develop practical guidelines and regulations. For managers, it is necessary to develop budget planning templates, a simplified LCC calculator, decision trees following technical inspections, minimum requirements for Terms of Reference (ToR) in tenders, and a set of key performance indicators (KPIs) for execution control.

Conclusion. The results show that the proposed system makes it possible to justify repair costs, plan them in advance, and optimize them. While maintaining quality at the required regulatory level, it ensures comfort and safety for residents during operation and guarantees the rational use of resources.

In future work, it is advisable to proceed in the following directions: introduce a digital-twin concept for the residential segment, further refine CBM strategies, develop a modular budgeting and monitoring platform for multi-apartment building management organizations, and expand a tailored normative-methodological package for different climatic zones and structural systems.

The head of state has also emphasized in several speeches the need to improve urban planning rules and align them with international standards [5]. The scientific principles, methodological approaches, and practical recommendations developed in this research can be applied to organizational and technological preparation, design, repair, reconstruction, and modernization processes in various types of residential buildings (multi-story, block, monolithic-frame, sites of historical heritage, etc.) and meet today's requirements. At the same time, they can also deliver effective results in the practice of management companies, homeowners' associations (HOAs), and local executive authorities.

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