Modern methods for extending the service life of buildings

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Abstract The article discusses the main methods and ways of extending the service life of buildings, in particular, maintaining its sustainability, functionality, safety and values. It is discussed, with modern methods, how to carry out a structural inspection of the structural elements of buildings, foundations, walls, ceiling and roofing elements in order to detect possible deformations or damages in time.

key word: Sustainability, functionality, security, Inspection and diagnosis, Foundations, walls, roof covering, Heating, ventilation, air conditioning.

Introduction

Modern urban development and the increasing physical and moral obsolescence of buildings pose a serious challenge to the safety and sustainability of infrastructure. For many buildings, especially those of economic or cultural importance, the extension of their service life is becoming relevant. This is due to both technical needs and environmental and financial considerations, which determine the maximum use of existing resources and the minimization of new construction. This process is accompanied by the introduction of innovative approaches and technologies, which not only ensure the preservation of the functionality of buildings, but also increase their efficiency and energy efficiency.

Main part

Extending the service life of buildings plays an important role in maintaining their sustainability, functionality, safety and value. There are several key conditions that are necessary to extend the life cycle of buildings:

1. Timely inspection and diagnostics

• Structural inspections should be conducted on the structural elements of buildings, foundations, walls, ceiling and roofing elements, in order to identify possible deformations or damage in a timely manner.

• Mechanical systems inspections should be conducted on the electrical, plumbing, heating, ventilation and air conditioning systems of buildings.

The inspections and diagnostic of the buildings should be conducted regularly, depending on the type of building, its age, and its condition.

In new buildings (0 to 10 years old), structural inspections should be performed once in every 5 years. Mechanical systems should be inspected annually, and electrical and plumbing systems should be inspected annually, but more frequently if there are high load and usage factors.

In middle-aged buildings (10 to 30 years old), structural inspections should be performed once in every 3 years. Mechanical systems should be inspected annually, and electrical and plumbing systems should be inspected once in every 6 months, with particular emphasis on systems that have become more sensitive due to age.

In older buildings (over 30 years old), structural inspections should be performed once in every 2 years or more frequently if the building is subject to heavy loads or structural deterioration. Mechanical systems should be inspected once in every 6 months, and electrical and plumbing systems should be inspected in every 3-6 months, with particular emphasis on safety issues to prevent accidents and malfunctions.

In high-risk buildings (public, industrial, public places), structural inspections should be carried out once a year, and mechanical systems should be inspected once a year or more often, depending on the intensity of use. Electrical and plumbing systems - once in every 3-6 months, since safety standards in

public places should be particularly high.
Best practice provides the frequency of inspections, which depends on the age of the building, the nature of use and environmental conditions. Regular inspections and diagnostics help to detect potential problems in time and avoid more serious difficulties and costs in the future.

2. Preventive maintenance

- Repair minor damage or malfunctions to prevent major problems.
- Regularly clean systems, lubricate them, and perform other preventive maintenance to keep them functioning.

Preventive maintenance of buildings includes various activities aimed at regular inspection, maintenance and repair of building elements and systems to prevent malfunctions and damage. These measures reduce long-term costs and ensure the proper functioning, safety and extension of the building's life cycle.

Services of structural element

- Periodically inspect the condition of the foundation, detect cracks and crevices. If necessary, reinforce the foundation.
- Inspect the condition of the walls and ceilings for cracks and damage. Check the condition of the thermal insulation.
- Inspect and maintain the roofing material to prevent leaks and water ingress. Clean the roof before the winter season.
- Service mechanical systems: In heating, ventilation and air conditioning systems:
- Regularly change filters to ensure clean air supply.
- Clean the condenser tubes to prevent condensate accumulation and difficulties in the operation of the system.
- Check the proper operation of the sensors so that the system regulates the temperature correctly.

In plumbing systems, check:

- The condition of plumbing pipes to detect malfunctions, leaks, and corrosion.
- Water pressure periodically to ensure the system is working properly and does not cause interruptions.
- Drainage systems should be cleaned periodically to remove accumulated debris and prevent interruptions.

3. Electrical systems maintenance, check:

- Electrical distribution boxes, for overheating, cracks or other damage.
- The condition of transmission lines and if damage or deformation is detected, their timely replacement.
- The operation of automatic circuit breakers and their replacement if necessary.

4. Emergency systems maintenance, check:

- Fire protection systems, such as fire detectors, water distribution systems and emergency exits.
- Emergency lighting systems and their operation.
- Security and alarm systems, including cameras and sensors.

5. Management of necessary materials and supplies

- It is necessary to manage the supplies of materials required for repair work so that they can be accessed quickly and easily if necessary.
- It is necessary to periodically check the condition of technical equipment, tools and materials and update them.

6. Construction and Repair Planning

- Within the framework of preventive maintenance, it is necessary to determine priority repair works and their timely implementation.
- If necessary, repair and modernization works should be planned, which will ensure the improvement of the functionality and safety of the building.

Repair works

In order to prevent premature failure of buildings and to effectively manage their exploitation, a number of necessary systems of

planned preventive repairs have been established, which include organizational and technological measures, examination and repair of structures, sanitary-technical systems, engineering equipment, as well as their maintenance and adjustment according to a pre-prepared plan. Timely and high-quality repairs ensure the normative terms of the service of buildings.

Planned renovation: Periodic planning of renovation works ensures the renewal of the main elements and systems of the building.

Full renovation: If necessary, the renovation carried out includes the renewal of both structural and visual and functional elements. There is the following classification of renovation:

- Planned-preventive (complex) repair;
- Selective repair;
- Planned-preventive (preventive) current repair;
- Adjustment and maintenance of sanitary-technical systems and building engineering equipment;
- Emergency (unscheduled) current repair.

Repair involves the replacement of unsafe elements of a building or the restoration of engineering equipment structures in the event of their physical and moral wear and tear, as well as increasing the level of amenities.

The main type of repair of residential buildings is planned-preventive (complex) reapir, i.e. repairs to restore the operational properties of all unsafe elements, the service life of which is equal to the inter-repair cycle. The inter-repair cycle is called the duration of the operation of building elements between repairs. During complex repair, the simultaneous restoration or replacement of all unusable structures and engineering equipment and the improvement of the building's amenities are provided: redevelopment of utility apartments into residential apartments, arrangement of elevators, garbage chutes, etc.

During selective repair, individual structures or their elements that have partially worn out are replaced and their repair cannot be postponed until the next planned preventive repair.

Current repairs are related to the daily operation of the building. It includes works that are systematically carried out to detect premature wear of building structures and engineering equipment. The physical condition of the structures is not changed, but they are preserved in the design state. The time for carrying out planned preventive (preventive) current repairs of the facility is planned in advance. This type of repair is the main factor in ensuring the preservation of the building.

Emergency (unscheduled) current repairs provide for the rapid restoration of unscheduled minor damage.

Repair and construction works can be carried out with the evacuation of residents (partially or completely) or without it. In order to reduce the time required for repairs without eviction, it is necessary to take into account the maximum combination of repair and construction processes and industrialization.

Construction and repair works should be carried out on the basis of a work production project, which takes into account: the development of the necessary technical documentation, the organization and technology of repair of individual objects or their groups, the sequence of works, the timing of their implementation, the demand for labor, the supply of materials and semi-finished products, machines and mechanisms, the arrangement of open and closed warehouses, engineering communications, household premises and other temporary structures at construction sites.

7. **Ongoing monitoring and reporting** - It is necessary to constantly monitor the condition of building systems in order to quickly identify potential problems; to document the results of inspections and services, which ensures the robustness of technical solutions.

Preventive maintenance of buildings includes systematic measures that ensure the proper functioning, safety and extension of the life cycle of structural and mechanical systems. These processes include inspection, repair, improvement and continuous

monitoring, which prevents failures in the first place and allows us to optimally manage building resources.

To improve resilience to seismic and other natural disasters, it is necessary to strengthen the building structure to withstand earthquakes and other natural disasters. To assess the risk of natural disasters, it is necessary to develop strategies to minimize damage in the event of natural events.

A building monitoring system involves the implementation of a continuous monitoring system that monitors the condition of building structures and mechanical systems. An integrated building management system (BMS) is a system that integrates all key technical and safety processes, ensuring effective building management and extending the life of the building.

8. Implementation of energy efficiency and environmental practices

Energy-efficient technologies significantly reduce energy consumption and contribute to the sustainable development of buildings. Their implementation not only contributes to energy savings, but also reduces greenhouse gas emissions and improves the overall comfort of buildings. The following are the main energy-efficient technologies that can be used during the construction and modernization of buildings:

Thermal insulation

- High-performance thermal insulation materials, such as polyurethane foam, extruded polystyrene (XPS), and fiberglass, reduce heat loss from the walls, floors, and roof of a building.
- Thermally insulated windows - double or triple glazing, which provides high thermal insulation and reduces heat loss through windows.

Renewable energy sources

- Solar panels convert sunlight into electricity. This system contributes to the energy independence of the building.
- Geothermal heating systems use the heat of the earth to heat and cool the building, which ensures a constant temperature and energy savings.

Heating, ventilation, and air conditioning (HVAC)

- Heat recovery ventilator (HRV) - recovers heat from the exhaust air and transfers it to the incoming air, which reduces heating and cooling costs.
- A heat pump is used to heat or cool water, which reduces energy consumption.

Intelligent Building Management Systems (BMS)

- Building automation - are intelligent systems that control lighting, heating, ventilation and air conditioning, ensuring efficient energy management. These systems use sensors and algorithms to optimize energy consumption.
- Timers and motion sensors - Lighting and other electrical devices are controlled by timers and motion sensors, which reduces energy consumption when no one is in the building.

For energy-efficient lighting, it is recommended to use efficient LED lamps rather than traditional incandescent lamps, which consume 75% less energy.

- When designing a building, glazing areas and their arrangement should be considered to maximize the use of natural light, which reduces the need for artificial lighting.

For energy-efficient windows and doors - the use of low-emission (Low-E) glass helps maintain internal temperatures. Air-tight doors and windows ensure minimal heat loss.

Energy-efficient management of water resources

- The use of solar panels for water heating reduces energy consumption.
- Rainwater collection and use systems reduce water consumption and energy consumption during its recycling.

Green roofs and facades provide additional thermal insulation, reduce building cooling costs and improve the microclimate, as well as vertical green gardens on facades, create additional thermal insulation and improve the ecological sustainability of the building.

The use of energy-efficient

technologies in housing construction creates environmentally friendly and economically beneficial spaces. Their implementation significantly reduces energy consumption, improves building comfort and safety, and ensures sustainable development.

- It is desirable to use environmentally friendly and sustainable building materials that contribute to the assessment of environmental impact.
- Low-emission building materials are characterized by low energy consumption in the production process and low environmental impact.
- The use of recycled and secondary materials reduces the consumption of primary resources and energy consumption.

Financial management and investments

- A long-term financial plan is a plan that includes covering the costs of maintaining, repairing and modernizing the building.
- Investments in innovative technologies ensure the extension of the building's life cycle and reduce costs.

Conclusion

Extending the service life of a building depends on a comprehensive approach that includes regular inspections, preventive maintenance, the use of energy-efficient and sustainable materials, as well as ongoing monitoring and financial management. Given these conditions, it is possible to maintain the longevity and safety of a building, which ultimately increases its value and environmental sustainability.

Reference

1. Durability Design of Concrete Structures in Severe Environments. In Durability of Materials and Structures in Building and Civil Engineering, ed. C.W. Yu and J.W. Bull. Whittles Publishing, Dunbeath, Scotland, pp. 106–127.

2. Concrete: Microstructure, Properties, and Materials, 4th Edition. P. Kumar Mehta, Ph.D.Paulo J. M. Monteiro, ISBN: 9780071797870. Publication Date & Copyright: 2014 McGraw-Hill Education

3. Eurocode - Basis of structural design, © 2002 CEN All rights of exploitation in any form and by any means reserved worldwide for CEN national Members. pp.116.

4. Research papers from journals like *Construction and Building Materials*, *Journal* of Structural Engineering, *and* Cement and Concrete Composites.