UDC 728.1+69.059.38 DOI: 10.31650/2786-6696-2024-8-102-109

METHODS OF RENOVATION OF MULTI-STORY RESIDENTIAL BUILDINGS IN MODERN UKRAINE

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Abstract. The current situation in Ukraine shows that the restoration of multi-story residential buildings is one of the most important problems of society. Existing research is mostly focused on assessing the technical condition of buildings to extend their service life or repair damage caused by uneven settlement of foundations and other operational factors. Since high-rise reinforced concrete buildings for residential and public purposes were usually designed and built without taking into account possible loads from military conflicts, as well as due to the lack of practical experience in their restoration and strengthening, the issue of ensuring their operational suitability and restoration is very relevant. To the stages of the building operation process, as a single technological process, in the event of damage with: inspections, monitoring, planned, unplanned and major repairs and liquidation. The article analyzed the current state of damaged multi-story buildings, studied the accumulated experience of their inspection, and considered constructive and technological measures for their restoration and reconstruction. The structural features of panel houses make it impossible to replace destroyed or severely damaged structures with new factory elements due to the lack of technical access for installation. The most optimal solution is the construction of new structures on the site of destroyed ones using rolled profiles, reinforcement, monolithic concrete, bricks and aerated concrete blocks. Taking this into account, the perspective for further research is a more detailed study of the problem and the development of structural and technological solutions for the restoration of residential buildings with economic justification of the feasibility of their implementation. In addition, there is a need to supplement the current regulatory documents regarding the reconstruction of buildings damaged as a result of military conflicts.

Keywords: multi-storey residential buildings, reconstruction, inspection, restoration methods, major repairs.

Introduction. Military action leads to damage and destruction of a huge number of buildings and structures on the territory of Ukraine, in particular, residential buildings. Since panel construction was widely used in the 1960s-1980s and coincided with the mass industrial construction of housing, the number of such houses is huge. Accordingly, the number of damaged panel houses (both in relative and absolute terms) is also significant (Fig. 1). The structural solutions of such buildings and the long period of their operation (60 years) determine a number of peculiarities when performing their on-site inspection, researching the properties of construction materials, the spatial location and damage of individual structures, as well as establishing the technical condition, developing emergency measures and technical solutions for strengthening the load-bearing structures.

In modern Ukraine, high-rise buildings made of reinforced concrete for residential and public purposes are often designed and built without taking into account possible loads that may arise as a result of military conflicts. This led to limited information about possible damage to load-bearing structures and lack of practical experience in their restoration and strengthening.

Fig. 1. Damaged multi-story residential buildings in the city of Kharkiv

Replacement and strengthening of individual load-bearing structures of panel houses with I and II categories of damage according to [1] makes it possible to quickly restore their operational suitability. But determining their technical condition, developing technical solutions and working drawings for reinforcement can take several months. The main reasons for the significant duration of this complex of works are: restrictions on access to structures (the need for initial inspection by explosives technicians, dismantling of destroyed structures, manufacture (in some cases) and installation of temporary supports and fasteners), conducting a full-scale visual and instrumental inspection of damaged structures, and, actually, time for the development and coordination of project solutions both with expert organizations (at the stage of examination of project documentation) and contracting organizations (regarding the availability of materials and equipment for procurement) [2].

Analysis of recent researches and publications. The work of scientists I.V. Shumakov [3-5], O.V. Samorodov [6, 7], O.V. Starkova [8, 9], D.O. Bondarenko [8, 9], and O.S. Molodeda [10-12] and others is devoted to issues of increasing the efficiency of restoration works of residential buildings and structures. Since multi-story reinforced concrete buildings for residential and public purposes were usually designed and built without taking into account possible loads from military conflicts, as well as due to a lack of practical experience in their restoration and strengthening, there are almost no publications in the domestic literature on the examination of buildings damaged during hostilities and the development of technical solutions for their restoration and ensuring operational suitability. Existing studies usually focus on assessing the technical condition of buildings in order to extend their service life or repair damage caused by uneven settlement of foundations and other causes.

The purpose and objectives of the research. The purpose of the study is to solve the problems associated with the restoration of multi-storey buildings in recent years during the military conflict, it is necessary to consider and analyze the current state of damaged buildings, analyze the accumulated experience in inspecting such buildings, as well as a review of constructive and technological measures for restoration and reconstruction..

The main part. The decision regarding the need to repair or strengthen building structures in order to restore or increase their bearing capacity and operational technical suitability is made on the basis of data obtained during their inspection, engineering investigations, as well as taking into account the results of verification calculations performed in accordance with the relevant regulatory documents.

It is recommended to choose a method of repair or strengthening on the basis of a technical and economic comparison of project solutions, taking into account further changes in operating costs.

The decision to strengthen structures is recommended after it has been established that other methods of ensuring reliability, such as the redistribution of technological loads, the use of effective materials for coatings and enclosing structures, the use of temporary unloading elements and means necessary for the installation and dismantling of equipment, are impossible or impractical .

To the stages of the building operation process, as a single technological process, in the event of damage with: inspections, monitoring, planned, unplanned and major repairs and liquidation. Based on the monitoring results, decisions are made on: continuation of operation; increasing monitoring volumes to identify the causes of the defect; elimination of the cause of the defect; development and implementation of measures to restore operational suitability.

Repair works of buildings and structures, depending on the condition of the supporting and enclosing structures, are divided into two types:

– ongoing repair (for normal and satisfactory condition);

– major repairs (for the condition of buildings (structures) or individual structures that are unsuitable for normal operation).

Summarizing the results of the survey conducted by the researchers of residential buildings, in particular panel high-rise buildings, damaged during hostilities, makes it possible to identify five main types of damage to load-bearing structures. In some cases, the restoration of damage to the filling of panel joints and surface damage to the outer layer of wall panels can be performed during current building repairs. Significant damage to load-bearing structures, such as: mechanical damage to panels as a result of hitting neighboring structures or the impact of a blast wave; mechanical damage to panels as a result of direct ammunition hits; mechanical damage to the panels as a result of fire, are subject to restoration only during capital repairs of panel houses or their individual parts.

Capital repair of buildings and structures can be comprehensive, covering the building or structure as a whole, or selective, consisting of the repair of individual structures of the building, structure or a separate type of engineering equipment.

Selective overhaul is carried out:

– if the complex repair of the building can cause serious obstacles in the work of the enterprise;

– with heavy wear of individual structures;

– when it is not economically feasible to carry out complex capital repairs.

Current, capital repairs and reconstruction must be carried out in compliance with the current rules of production organization and acceptance of repair and construction works, labor protection and fire safety rules.

Capital repair of buildings and structures includes such works, in the process of which replacement and strengthening of worn structures and parts of buildings and structures is carried out or their replacement with more progressive and economical ones that improve the operational capabilities of objects, with the exception of complete replacement or replacement of main structures, which have the longest service life (stone and concrete foundations, all types of building walls, all types of wall frames, underground network pipes, bridge supports, etc.). An example list of overhaul works is given in Table 1.

Table 1 – An exemplary list of works on capital repair of buildings and structures

№	Process	Characteristic
1	Foundations	Replacing wooden chairs or replacing them with stone or concrete pillars; partial relocation (up to 10%), as well as strengthening of stone foundations and basement walls, which is not related to the superstructure of the building or additional loads from the supplied equipment; restoration of vertical and horizontal insulation of foundations; restoration of the existing paving around the building (more than 20% of the total area of paving).
2	Walls and columns	Filling of cracks with clearing of furrows, with tying of seams to the old masonry; arrangement and repair of structures that strengthen stone walls; repositioning of old brick cornices, jumpers of parapets of pits and projecting parts of walls; relocation and repair of individual old sections of stone walls (up to 20% of the total volume of masonry), which are not related to the superstructure of the building or additional loads from the supplied equipment; reinforcement of reinforced concrete and stone columns with clips; repair and partial replacement (up to 20% of the total volume) of columns not related to additional loads from the installed equipment; replacement of fillers in walls with a stone, reinforced concrete and metal frame (up to 40%); replacement of old crowns of log or block walls (up to 20% of the total wall surface); solid construction of walls made of logs and beams; partial replacement of claddings, backfills and plate insulation of frame walls (up to 50% of the total area of the walls); replacement or repair of cladding and insulation of wooden plinths; repair of stone plinths of wooden walls with their relocation up to 50% of the total volume; installation of new and replacement of worn wall clamps made of logs and beams.
3	Partitions	Repair, change and replacement of all types of worn partitions with more progressive designs; in the case of capital repair of partitions, partial re-planning with an increase in the total area of partitions up to 20% is allowed.
4	Roofs and coverings	Replacement of old roof trusses or their replacement with prefabricated reinforced concrete; total or partial replacement of beams, crossbars, purlins; total or partial replacement of old metal and reinforced concrete trusses, as well as replacement of metal with prefabricated reinforced concrete trusses; reinforcement of trusses when replacing types of covering, when hanging lifting devices, as well as when corrosion of nodes and other elements of metal and reinforced concrete trusses; partial or total replacement of steps, mauerlats and scaffolding; partial or complete replacement of old covering elements, as well as replacing them with more progressive and durable ones; partial (more than 20% of the total roof area) or total change or replacement of all roof elements;
5	Interfloor ceilings and floors	Repair or replacement of floor coverings; replacement of individual structures or ceilings as a whole with more progressive and durable structures; reinforcement of all types of inter-floor and attic floors; partial (more than 10% of the total floor area in the building) or total replacement of all types of flooring and its base; refurbishing the floor during repair with replacement for stronger and more durable materials.
6	Windows, doors	Complete replacement of old window and door blocks, as well as gates of production buildings; replacement and strengthening of all types of stairs and their individual elements.

Continuation of Table 1

7	Internal plastering, facing and painting works	Restoration of plaster of all premises and repair of plaster in the amount of more than 10% of the total area of plastered surfaces; replacement of wall coverings in the amount of more than 10% of the total area of covered surfaces; general anti-corrosion painting of metal structures.
8	Facades	Repair and restoration of facing with an area of more than 10% of the facing surface; full or partial (more than 10%) plaster restoration; complete restoration of beams, eaves, belts, sandriks, etc.; restoration of moldings; general painting with stable mixtures; cleaning facades with sandblasting devices; replacement of balcony slabs and fences; replacement of the covering of protruding parts of the building.
9	Central heating	Replacement of individual sections and assemblies of heating boilers, boilers, boiler units or complete replacement of boiler units; repair and replacement of expanders, condensation pots and other network equipment; repair and relocation of foundations for boilers; automation of boiler houses; replacement of heating registers; connection of buildings to the heating network (when the distance from the building to the network is no more than 100 m).
10	Ventilation	Partial or complete replacement of air ducts; replacement of fans; rewinding and replacement of electric motors; replacement of shutters, deflectors, throttle valves, blinds; partial or complete replacement of ventilation boxes; replacement of radiators; replacement of heating units; replacement of filters; replacement of cyclones; replacement of individual camera structures.
11	Water supply and sewerage	Partial or complete replacement of the pipeline in the middle of the building, including water supply inlets and sewage outlets; partial or complete replacement of pipeline insulation; replacement of parts or complete replacement of pumping units of pumping systems; repair and replacement of pressure tanks.
12	Hot water supply	Replacement of coils and boilers; replacement of the pipeline, parts and in general pump units, tanks and pipeline insulation.
13	Electric lighting and communication	Replacement of worn parts of the network (more than 10%); replacement of safety shields; repair and restoration of cable channels; replacement of lamps with other types is permitted during network overhaul.

During the restoration of Ukraine's independence, large-panel construction began to lose popularity. It is not technically possible to manufacture separate prefabricated elements for most of the series of panel houses in operation. In addition, the cost of such elements, including logistics, becomes unacceptably high. The structural feature of panel houses is such that it is almost impossible to replace a destroyed or severely damaged structure with a factory-made element for objective reasons, namely: lack of access for installation. In view of the above, the most expedient solution is the manufacture of separate structures to replace the destroyed ones on the spot using rolled profiles, reinforcement, concrete, bricks and aerated concrete blocks (Fig. 2). In some cases, it is possible to use prefabricated reinforced concrete elements, for example, floor slabs.

In modern Ukraine, high-rise reinforced concrete buildings for residential and public needs are often designed and built without taking into account possible loads that may arise as a result of military conflicts. This leads to insufficient information about the nature of damage to load-bearing structures and the lack of practical experience in their restoration and strengthening.

Fig. 2. Restoration of damaged multi-storey residential buildings in the city of Kharkiv

Studies of damaged buildings show that the stiffness of the entire building may be sufficient, but that individual parts such as shells and floors are significantly damaged. For the restoration of such buildings, the use of metal structures for reinforcement and the use of monolithic reinforced concrete structures that are reliably connected to the surviving elements are recommended.

Monolithic reinforced concrete structures, which are made using tunnel formwork, can be effective, which increases the overall rigidity of the building and strengthens local damage zones. A detailed examination of the building using modern equipment to determine its technical condition and strength of individual elements also plays an important role.

A general list of recommendations on structural, technological and theoretical calculation measures will help to significantly increase the reliability and safety of operation of damaged buildings and structures.

Conclusions and directions for future research. So, as a result, an analysis of the current state of damaged multi-story buildings, an analysis of the accumulated experience of surveying such buildings, and a review of constructive and technological measures for restoration and reconstruction were carried out. Analysis of surveys of damaged buildings allows us to conclude that such buildings

are subject to restoration only with major repairs or their individual parts. The structural feature of panel houses does not allow replacement of a destroyed or severely damaged structure with a new factory-made element due to the lack of technical access for installation. In this context, it is necessary to review the parameters of sections and reinforcement in order to increase them. For example, for ceilings and other elements of buildings, it is recommended to increase the thickness of reinforced concrete slabs to at least 250 mm and increase the percentage of reinforcement to at least 2.5%. Also worth considering is the need for protective shelters similar to those used in Israel, Iran and other Middle Eastern countries.The most expedient solution is the construction of separate structures to replace those destroyed on the spot using rolled profiles, reinforcement, monolithic concrete, bricks and aerated concrete blocks. In this regard, the prospect for further research is a more detailed examination of the problem and the development of constructive and technological solutions for the restoration of residential buildings. Also, it should be noted that there is a need to supplement the current normative documents on the reconstruction of buildings damaged as a result of military conflicts.

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МЕТОДИ ВІДНОВЛЕННЯ БАГАТОПОВЕРХОВИХ ЖИТЛОВИХ БУДИНКІВ В СУЧАСНІЙ УКРАЇНІ

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Анотація. Сучасна ситуація в Україні свідчить про те, що відновлення багатоповерхових житлових будинків є однією з найважливіших проблем суспільства. Наявні дослідження здебільшого зосереджені на оцінці технічного стану будівель для продовження терміну їх експлуатації або усунення пошкоджень, спричинених нерівномірним осіданням фундаментів та іншими експлуатаційними факторами. Оскільки багатоповерхові залізобетонні будівлі житлового та громадського призначення зазвичай проектувалися та будувалися без урахування можливих навантажень від воєнних конфліктів, а також через відсутність практичного досвіду з їх відновлення та посилення, питання забезпечення їхньої експлуатаційної придатності та відновлення є дуже актуальним. До етапів процесу експлуатації будівлі, як єдиного технологічного процесу, при пошкодженні є: обстеження, моніторинг, плановий, позаплановий і капітальний ремонти та ліквідація. У статті було проведено аналіз поточного стану пошкоджених багатоповерхових будівель, вивчено накопичений досвід їх обстеження та розглянуто конструктивно-технологічні заходи для їх відновлення та реконструкції. Конструктивні особливості панельних будинків унеможливлюють заміну зруйнованих або сильно пошкоджених конструкцій новими заводськими елементами через відсутність технічної можливості доступу для монтажу. Найбільш оптимальним рішенням є зведення нових конструкцій на місці зруйнованих з використанням прокатних профілів, арматури, монолітного бетону, цегли та газобетонних блоків. Враховуючи це, перспективою для подальших досліджень є детальніше вивчення проблеми та розробка конструктивно-технологічних рішень для відновлення житлових будівель з економічним обґрунтуванням доцільності їх впровадження. Крім того, існує потреба у доповненні чинних нормативних документів щодо реконструкції будівель, пошкоджених внаслідок воєнних конфліктів.

Ключові слова: багатоповерхові будинки, реконструкція, обстеження, методи відновлення, капітальній ремонт.

Стаття надійшла до редакції 30.05.2024