UDC 539.3:620.012:691.15:643.001 DOI: 10.31650/2415-377X-2022-86-35-46

DEGRADATING CONCRETE AND REINFORCED CONCRETE BUILDING STRUCTURES AND LONG-TERM STRUCTURES

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Abstract. The problems of degradation of concrete and reinforced concrete constructions of buildings and constructions of long operation are formulated on the basis of the performed field researches and its urgency is noted in the work. The authors analyzed a number of works on this problem. In particular, the results of technical diagnostics of many buildings and structures, both newly built and long-term operation, are described. The necessity of periodic technical diagnostics is noted. Based on these studies, the main factors that significantly affect the reduction of load-bearing capacity of reinforced concrete structures of buildings and structures are summarized and found that they are as follows: design errors, defects and shortcomings of construction and operational shortcomings of buildings and structures.

Also, using modern technologies and materials, the authors identified the benefits of their use for repair and restoration of concrete and reinforced concrete structures at a number of long-term facilities. Relevant conclusions have been formulated on research and repair works.

It is established that to prevent loss of load-bearing capacity of structures for long-term operation it is necessary to study the degradation and residual life of load-bearing capacity of structures, their reliability and durability, which were exposed to aggressive air, soil and water.

It is established that the reason for the decrease in the strength of concrete beams, which were operated in an aggressive environment, was the error in the design of corrosion protection of structures.

Reinforcement and injection filling of dry cracks, crevices and hidden cavities and stratifications and other corrosion damage of beams and slabs with the use of fluid polyurethane compositions, which allowed to extend the service life of structures.

It is established that the use of the Polymer Cement Concrete system with the use of glued composite materials ensured the further normal operation of the monolithic reinforced concrete floor of the technical floor of the residential building.

Recommendations for the sequence of operations in the repair of reinforced concrete structures of buildings and structures of long-term operation.

Keywords: concrete and reinforced concrete structures, degradation, corrosion, defects, carbonization of concrete, reinforcement.

The problem and its relevance. To a large extent, capital construction efficiency and quality depend on technical development and research of advanced materials, constructions and technologies, their rapid introduction into the construction practice. In particular, new facilities, as well as those buildings and structures that are subjected to reconstruction and a significant number of facilities and structures, the construction of which was stopped in the 80s due to lack of funding, and reorienting them to modern advanced technologies.

This brings to the forefront the problem of studying the degradation and residual resource of the bearing capacity of structures, their reliability and durability, which were subjected to long-term exposure to the aggressive effects of air, soil and water environments. Therefore, the problem of ensuring and restoring the strength and durability of buildings and structures is relevant and timely.

Thus, our task in this work and in future, based on numerous studies by authors (more than 50 objects), partly cited in the research analysis and cited in the literature, is to identify and summarize the main design errors, defects and shortcomings of construction and shortcomings of long-term operation of buildings and structures.

Analysis of recent research and publications. Critical analysis and synthesis of scientific and technical sources [1-10] suggest that in the last two decades the scientific direction of researching long-term buildings and structures, which suffer from aggressive air, soil and water environments have been formed and developed. These researches are aimed at applying modern materials and technologies.

Let's consider some of them, in particular in the authors' first monograph [1] "Methods of improving corrosion resistance and durability of concrete and reinforced concrete structures" the main corrosion kinds and types and their impact on long-term reinforced concrete structures and buildings, and methods of restoring the load-bearing capacity and durability of buildings and structures from these structures are summarized. Considerable attention is paid to the theoretical substantiation of bases of mathematical modeling of corrosion destruction and corrosion degradation of cement conglomerates of concrete and reinforced concrete type.

In work [2], the author cited the studies' results of degradation of reinforced concrete structures of the subways in are described. The main structural defects are described and the causes of their appearance and consequences of their degradation are analyzed. Recommendations are also offered for restoring their operational characteristics to a technically standard state.

In work [3] the diagnostics results of the precast-monolithic constructions of the administration building stylobate stoneware in Lviv are described. In particular, photographic materials, which show significant destruction of the concrete of the stylobate beams nodes and corrosion of the contour beam exposed reinforcement are given. The conclusions indicate that the results of the studies allow determining the value of the residual load-bearing capacity of stylobate structures more reasonably. Also, during the diagnostic process, hidden voids, cracks and crevices are found, as well as open defects and damages are to be repaired by injection of the PCC system (Polymer Cement Concrete).

In work [4] the authors presented the results of researching the structures of the "Prykarpattya" hotel swimming pool and formulated proposals for restoring the operational characteristics of the structure.

In work [5], the foundations under the unloading supports of the gas pumping unit (GPU) of the pumping station were inspected and reinforced with modern materials of Pagel, and in paper [6] the corrosion of concrete and its effect on the bearing capacity of the foundations of air cooling units (ACU) at the compressor station "Oprah II" is also studied and recommendations for their strengthening are formulated.

In work [7], the authors considered the use of the Pagel system in the repair of long-term coal towers and in constructing and designing new ones. In paper [8] the authors describe the main problems of correct justifying the choice of anti-corrosion protection at the design stage and show the need of evaluating reliability indicators under state standards, taking into account the requirements of corrosion resistance, durability and repairability.

The case is considered when strengthening reinforced concrete structures must be strengthened with modern materials, which are given in paper [9] "Technology for strengthening monolithic reinforced concrete structures of the building floor in Kiev". In particular, the results of the overlap survey are presented, as a result, some design errors were identified. Based on research, it is proposed to strengthen the sub-support areas on the upper face of the plate for percepting negative bending moments and to strengthen the entire plate from the bottom for percepting positive bending moments. The essence of strengthening the sub-support areas was to increase the transverse

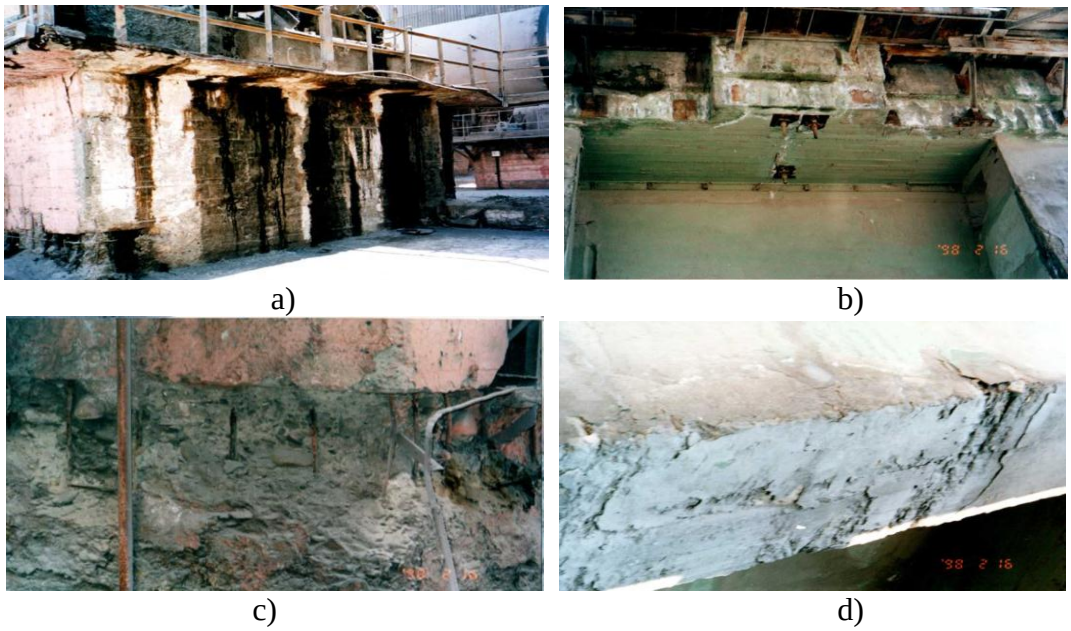
reinforcement with carbon tape, and slabs with tape materials in two directions, gluing with special adhesives Resin 220.

In work [10], the research on restoring the load-bearing capacity of reinforced concrete beams damaged by corrosion of an access railway track unloading unit is described. It is established that the reason for decreasing the concrete strength led to decreasing the load-bearing capacity of reinforced concrete beams and slabs. Composite materials like tapes and mats of carbon fiber, as well as modern technologies developed by the authors in work [9] are proposed to reinforce.

The research results of the authors given in works [1-10] are summarized in the monograph [11]. In particular, the main corrosion kinds and types, and factors influencing the mechanisms and kinetics of corrosion degradation of concrete and reinforced concrete buildings and structures are described, and methods for increasing the corrosion resistance and durability of concrete and reinforced concrete are proposed. And in work [12], the expediency of applying the method of membrane waterproofing of underground reinforced concrete structures with modern technologies and injection materials are shown.

The purpose of the work is to generalize the research results of degradated long-term concrete and reinforced concrete buildings and structures and to establish design errors, defects and construction shortcomings and operation shortcomings of such structures.

The main technical research results of long-term reinforced concrete structures. The experimental research was carried out on some objects at different times during their implementation on models. Let's present the research results of the technical condition of the structures of five objects, namely: load-bearing reinforced concrete structures of rotating furnaces in the cement plant in Mykolaiv (Fig. 1); reinforced concrete structures of the overpass at the Pridnestrovian hydroelectric power station in the Ivano-Frankivsk region (Fig. 2); reinforced concrete structures of plant "Three concretes" in Stryi (Fig. 3); parking reinforced concrete structures of a lot of the Bukovel ski resort (Fig. 4) and reinforced concrete beams-crossbars on the pool of hotel "Prykarpatye" in Truskavets (Fig. 5). Degradating reinforced concrete structures and their operation conditions in the objects' air environment are described in detail in the authors' works [13-19].



a) b) c) d)

Fig. 1. Degradation of load-bearing reinforced concrete structures of rotary kilns of a cement plant (Lviv region, Mykolaiv, 1998):
a – a general view of the foundations for rotating furnaces; b – the destruction of reinforced concrete walls and corrosion of reinforcement; c – the destruction of reinforced concrete structures of the technological site; d – a fragment of typical wall destruction and significant rebar corrosion

Based on the results of the objects' technical survey shown in Fig. 1-5, it is possible to generalize the characteristic features of the degradation properties of reinforced concrete structures. In particular, during the reinforced concrete structures survey at all five objects, significant damage and defects associated with long-term operation in the air environment and errors and shortcomings made during the design and construction of these objects are identified.

During the survey, several errors, defects, shortcomings, voids, chips and construction and operation shortcomings, separation of weak degraded concrete; exposed reinforcement, corrosion of reinforcement; contamination of concrete and metal elements' surfaces; cavities, cracks and sinks and chips; they were found on all reinforced concrete structures of the examined objects (Fig. 1–5).

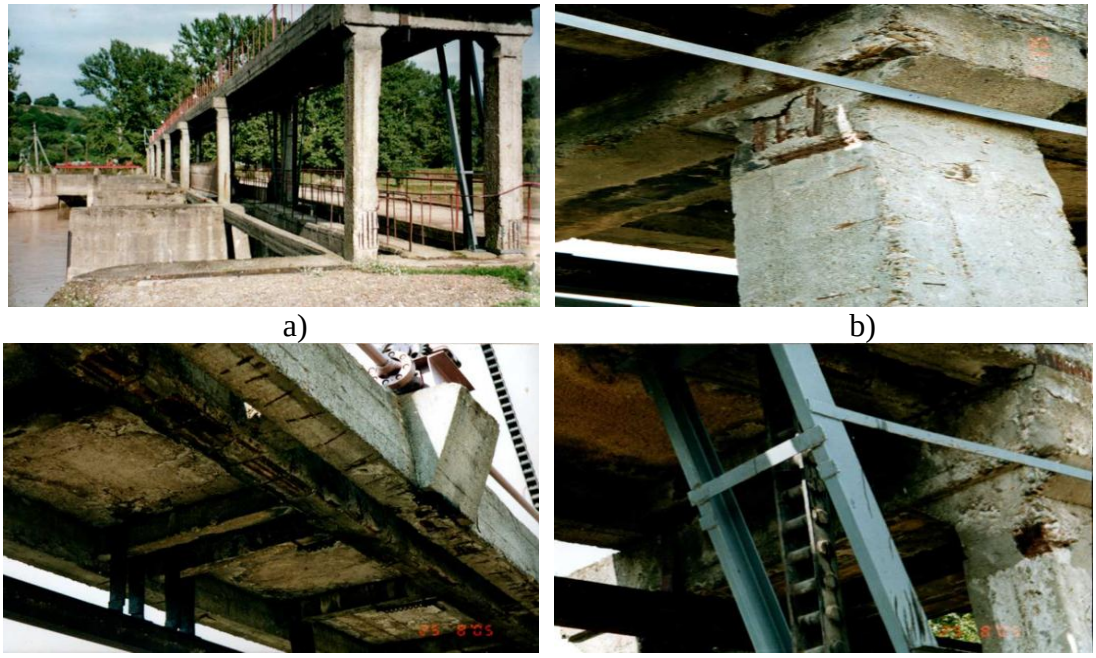


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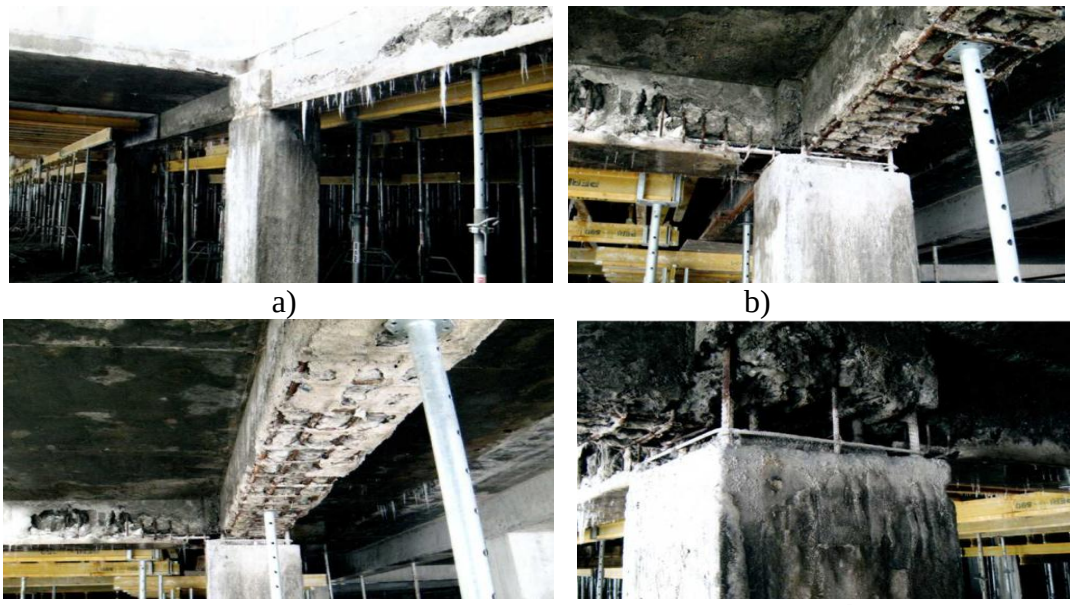
Fig. 2. Corrosion destruction of reinforced concrete overpass structures at the Pridnestrovian hydroelectric power station (Ivano-Frankivsk region, 1985):
a – a general view of the destruction of overpass structures; b – the significant concrete destruction of reinforced concrete columns and significant corrosion of reinforcement; c – a general down view of the destruction of concrete slabs and column capitals, and the significant corrosion of reinforcement; d – a fragment of the destruction of structures (down view) at the brace location

a) b) c)

Fig. 3. Destruction of reinforced concrete structures of the plant "Three Concretes" in Stryi (the Lviv region): a – the destruction of columns and walls with a crossbar; b – the destruction of concrete columns and significant corrosion of reinforcement; c – the concrete destruction of paired columns and significant corrosion of reinforcement in them

In particular, it should be noted that significant shortcomings and errors were made at constructing and concreting the ski parking lot in the Bukovel resort at negative temperatures (Fig. 4). In addition, reinforced concrete structures of rotary kilns of the cement plant (Fig. 1) were partially contaminated with engine oil. All these works require, first of all, practical skills of employees, while making the surface of a reinforced concrete structure free from various contamination kinds of corrosion products, in particular, carbonation of concrete, this is hard and time-consuming work.



a) b) c) d)

Fig. 4. Destruction of reinforced concrete structures of the parking lot in the Bukovel ski resort (Ivano-Frankivsk region, 2013):
a – a general view of reinforced concrete structures in the process of removing the formwork; b – the significant destruction of concrete and corrosion of the crossbar reinforcement from frost; c – the degradation of reinforced concrete crossbars from frost; d – the destruction of concrete at the junction of the crossbars with the column and corrosion of reinforcement from frost

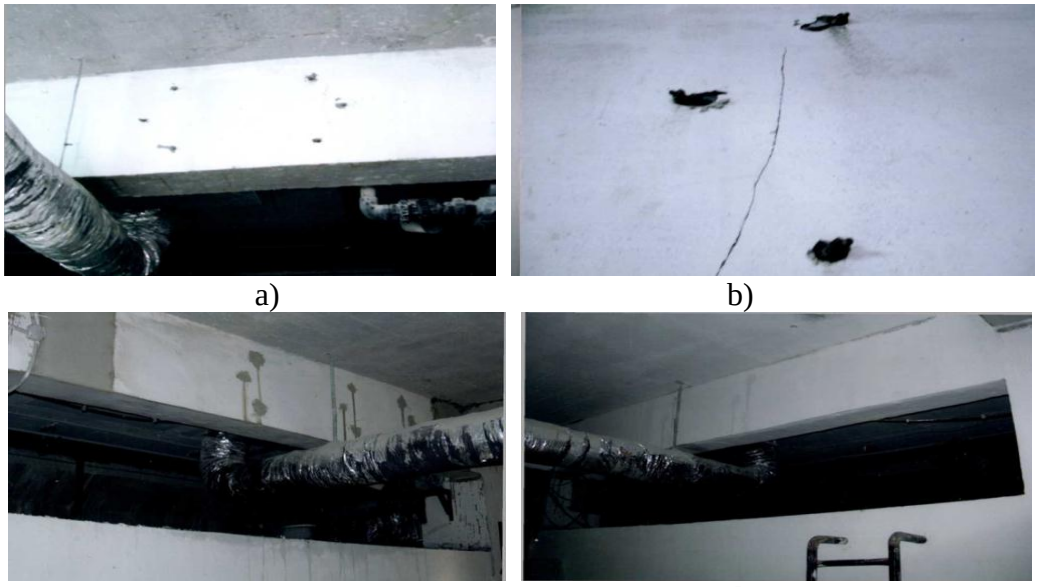


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Fig. 5. The destruction of a reinforced concrete crossbar beam on the pool of the Prykarpatye hotel in Truskavets (2006): a – a general view of the location of the packers; b – crack and packers, a close view; c – a view of the crossbar after dismantling the packers; d – a view of the crossbar after completing injection works

Based on several full-scale surveys of buildings and structures and scientific and technical sources given in the analysis, defects and damages and construction shortcomings can be generalized and used to establish the actual condition of long-term reinforced concrete buildings and structures. In particular, to eliminate some shortcomings and errors and establish the remaining resource of such structures.

Thus, based on the analysis and synthesis of scientific and technical sources and the examined objects shown in Fig. 1-5 the results can be summarized as follows:

Main errors made at the design stage of buildings and structures: a reduced protective layer of concrete in comparison with regulatory documents; excessive concentration of reinforcing bars, through which the package of working reinforcement makes high-quality concreting difficult; unsuccessful design solutions of drainage, as a result of which water gets on beams and supports, supporting reinforced concrete structures, accelerating the degradation of materials of these elements; unsuccessful solutions of expansion joints; construction of a plate of cement-concrete coating of the roadway of bridges without taking into account its actual stress-strain state.

Main defects and disadvantages of constructing buildings and structures: reducing the strength of concrete compared to the design; poor-quality concreting (too hard concrete, insufficient compaction) and caring concrete during strength gain, as a result of which sinks, pores, sedimentary cracks appear in it; lack of gaps between the ends of beams, which creates additional stresses from temperature deformations in superstructures; poor-quality waterproofing and coating, which contributes to the penetration of water on supporting structures; deviations from design solutions (lack of waterproofing on sidewalk consoles); poor-quality implementation of Beam and plate combinations, which leads to a violation of their joint work, violation of technology and installation of construction structures.

Main disadvantages of operating buildings and structures: potholes, inflows on the roadway that creates an additional dynamic effect on structures; cracks in the coating and destruction of waterproofing, water impregnation on beams and supports; destruction of expansion joints; carbonation of concrete; corrosion of concrete and reinforcement; the appearance of cracks in load-bearing reinforced concrete structures and their unacceptable opening.

Repair and restoration work of characteristic defects and damages of long-term buildings and structures. During repair and restoration work, a reliable PCC (Polymer Cement Concrete) system is mainly used in Ukraine. In particular, in practice, so-called modified concretes are widely used: polymer concrete-like compositions CPC-Concrete Polymer Composites, which can be divided into three such groups:

1. Polymer-Cement Concretes PCC-Polymer Cement Concrete.
2. Concretes impregnated with PIC-Polymer Impregnated Concrete.
3. Resin-based concretes-PC-Polymer Concrete.

Modification of CPC-Concrete Polymer Composites depends on the polymer type, the polymer amount, the type in which the polymer is introduced (monomer, prepolymer, liquid resin, solution, emulsion, powder) and the method of application to concrete.

Based on the analysis of scientific and technical sources and performed repair and restoration work at many facilities [2, 3, 5, 6, 10] and initial corrosion of reinforcing steel was detected in the reinforced concrete structure prepared for repair (Fig. 1-5) so it is best and most economical to perform the following surface preparation operations sequentially [10, 18]:

– identify all cavities by tapping and clearing them;
– completely expose the reinforcement, if it is corroded;
– make the sandblasting of the concrete surface;
– check the concrete for alkalinity;
– carry out steel preservation with an anti-corrosion agent.

These operations are described in detail in the authors' work [18]. The authors also pay attention to the system of repairing and restoring reinforced concrete structures by the PCC system and its advantages:

– mineral-based repair system allows performing work in conditions of a moistened base;
– the products of the system have significant strength for dynamic loads;

– minimum specific shrinkage during the solidification of solutions;

– the system products are weather-resistant;

– the repaired surfaces can be fully loaded in 24 hours;

– the main products of the system are delivered in the dry mix.

Technological operations about using a system for repairing and restoring concrete and reinforced concrete buildings and structures are described in more detail in the works [1, 11], and methods for determining a load of crack formation for assessing the corrosion resistance of reinforced concrete structures are given in work [19].

Thus, reinforced concrete restoration systems are used in different combinations depending on the needs. After restoring reinforced concrete surfaces of buildings and structures (if necessary) shown in Fig. 1-5 performed reinforcement with composite materials according to the schemes given in [1, 11].

Load-bearing reinforced concrete structures should be thoroughly cleaned off concrete corrosion products, etc. To perform a reprioritization (levelling) of reinforced concrete walls and wall supports, as well as connecting joints (dilatations) for various purposes with the ASOCRET-PCC concrete repair system or Pagel system.

The above recovery systems and technologies can be used for all objects shown in Fig. 2-5, except for reinforced concrete structures of the cement plant, which are partially impregnated with machine oil. A special feature of the structures shown in Fig. 1 there is that they require additional special degreasing works – the first – manual mechanical cleaning; the second – milling the greasy surface to a depth of 3-4 mm; the third – applying the coupling layer manually with brushes using Pagel-MS02 material.

When repairing reinforced concrete structures in Fig. 4 in Bukovel it is necessary to perform the following operations:

– to cut (separate) frozen concrete layers;

– to concrete individual sections of structures (or shotcrete), up to the design cross-sections of structures with maintaining the required concrete strength;

– to clean up bumps and swells on structures;

– to check the load-bearing capacity of structural elements if necessary, strengthen the zones with composite belts.

Individual concrete walls and load-bearing reinforced concrete of buildings and structures require local compaction by injection methods in places where cracks appear, as well as in places of point leaks. In addition, in some places of load-bearing reinforced concrete structures, it is necessary to perform force reinforcement by gluing composite tapes and mats: compaction is performed by injection using plastic polyurethane compositions XSODUR–P1 and ASODUR-P4.

Power reinforcement of wall structures is performed by injection using ASODUR-IH/W epoxy composite. To close cracks, it is recommended to inject epoxy-polyurethane composites such as ASODUR-P1, ASODUR-P4.

The technology of carrying out repair and restoration works (preparation of the wall surface in the area of the borehole device, installing packers, working with an injection gun, filling boreholes with repair materials, etc.) is described in detail by the authors in works [1, 11] and shown in Fig. 1–5. In particular, the reinforcement of crossbars and floor slabs (coatings) with carbon belts according to the appropriate methods is given by the authors in works [1, 10, 11, 18-19].

It should be noted that the development of methods for increasing the durability of reinforced concrete structures in recent years is an urgent task, which is reflected in many scientific works. Namely, in works [20-22] for the restoration of concrete structures, the latest methods for reconstructing and repairing bridges are proposed. In work [23] it is noted that the issues associated with the occurrence of deformations of concrete slabs of road bridges in the initial period of its hardening remain unresolved.

For this purpose, in work [24], it is proposed to improve the quality of concrete by changing the composition of materials. In addition, in work [25] it is noted that the reliable structure of

concrete depends on the processes during concreting and the conditions of primary hardening. In work [26], it is proved that the moving load on the bridge during concrete work contributes to the occurrence of deformations and affects the structure of finally uncured concrete. All this allows concluding that further searches are needed for the effective repair of damaged and defective reinforced concrete structures.

Scientific novelty and practical significance. In this work, based on the analysis and synthesis of scientific and technical sources and several studies of long-term reinforced concrete structures of real objects, data on the processes that affect their degradation are summarized. In particular, the main causes of the degradation of reinforced concrete of buildings and structures have been identified. These are errors at the design stage, defects and construction shortcomings, and operational shortcomings.

Based on the obtained data provided in several scientific and technical sources and research performed by the authors, the method of technical diagnostics of long-term reinforced concrete structures of objects and the method of strengthening them using modern materials and technologies were worked out. In practice, using these techniques makes it possible to significantly increase the resource and reliability of these structures.

Conclusions. Based on the analysis and synthesis of scientific and technical sources and surveys of several objects and diagnostics of the technical condition of long-term buildings and structures, the following conclusions can be formed:

1. Based on the completed field surveys and technical diagnostics of several objects of long-term buildings and structures on which the developed methodology and technology of repair and restoration works were applied, it can be stated that a significant increase in the durability and reliability of long-term concrete and reinforced concrete structures.

2. The developed technology of repair and restoration of concrete and reinforced concrete structures, which is based on using a modern regulatory and technical base of diagnostics and repair work, materials, devices and equipment, has proven itself in practical and economic aspects, has been successfully tested on real objects, in particular, during the repair of the pool in the building of the hotel "Prykarpatye", reinforced concrete foundations under the unloading supports of the GPA pumping station "Opora", reinforced concrete foundation ABO gas at the compressor station "Opora II", and the load-bearing structure of the hotel "Dniester" is reinforced in Lviv and others.

3. Often the repair of objects given in the analysis of scientific and technical sources and described in this work is associated with certain technical difficulties (especially the lack of technical documentation) because there is no clarity on many issues, for example, what should be the reinforcement of reinforced concrete structures, or how technical breaks were performed during concreting, or what class of concrete is embedded in the structure, etc.

4. From the above analysis and synthesis of research results of objects of long-term buildings and structures, in particular, load-bearing reinforced concrete structures of the hotel "Dniester", the pool of the hotel "Prykarpatye", the monolithic overlap of the technical floor of a residential building in Kyiv, and many other examined objects, the authors of this work found that despite the significant service life of some objects, design errors are made, defects (cracks, gaps, sinks) and construction shortcomings and long-term shortcomings, which lead to the need for major repairs, which in turn entails additional financial costs.

5. Research results of the administrative building stylobate in Lviv and repair and restoration works make it possible to more reasonably determine the amount of the remaining load-bearing capacity of the stylobate structure. Hidden cracks and crevices identified during technical diagnostics, as well as open defects and corrosion damage, were subject to repair with modern materials of the PCC system by injection.

6. Based on the studies of reinforced concrete beams and plates of the unloading unit of the access railway track it is established that the reason for the reduction of the concrete strength according to the theory of reinforced concrete, which were used in the environment (corrosion) caused a significant reduction in the load-bearing capacity of reinforced concrete beams over a long period of operation. Composite flowing polyurethane composites were used to reinforce and inject

the dry cracks, crevices and hidden voids, bundles and other corrosion damage of beams and plates, thus allowing the continuation of the service life of said structures.

7. Thus, based on the survey and technical diagnostics, the authors of this work have worked out the technology for strengthening reinforced concrete structures as a result of errors made during the design of structures of buildings and long-term structures. In particular, the use of the PCC system with glued composite materials ensured the further normal operation of the monolithic reinforced concrete floor covering of the technical floor of a residential building in Kyiv. Reinforced concrete beams and slabs of the unloading unit of the access railway track were also similarly reinforced with composite materials, namely carbon fiber belts and Mats. This reinforcement extended the service life of this facility.

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ДЕГРАДАЦІЯ БЕТОННИХ І ЗАЛІЗОБЕТОННИХ КОНСТРУКЦІЙ БУДІВЕЛЬ ТА СПОРУД ТРИВАЛОЇ ЕКСПЛУАТАЦІЇ

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Анотація. У роботі на основі виконаних натурних досліджень сформульовано проблеми деградації бетонних і залізобетонних конструкцій будівель і споруд тривалої експлуатації та відзначено її актуальність. Проаналізовано авторами низку робіт із вказаної проблеми. Зокрема, описано результати технічної діагностики багатьох будівель і споруд, як новозбудованих так і тривалої експлуатації. Відзначено необхідність періодичного проведення технічної діагностики. На підставі цих досліджень узагальнено основні фактори, що значно впливають на зниження несучої здатності залізобетонних конструкцій будівель і споруд та встановлено, що вони зводяться до наступного: до помилок допущених при проєктуванні, до дефектів і недоліків будівництва та до недоліків експлуатації будівель і споруд.

Також, використовуючи сучасні технології та матеріали, автори визначили переваги застосування їх для ремонтно-відновлювальних робіт бетонних і залізобетонних конструкцій на ряді об’єктів тривалої експлуатації. По дослідженнях та ремонтних роботах сформульовані відповідні висновки.

Встановлено, що для попередження втрати несучої здатності конструкцій довготривалої експлуатації потрібно проводити дослідження деградації та залишкового ресурсу несучої здатності конструкцій, їх надійності і довговічності, які піддавались довготривалій дії агресивного впливу повітряного, ґрунтового і водного середовищ.

Встановлено, що причиною зниження міцності бетону балок, які експлуатувалися у агресивному середовищі, стало допущення помилок із проектування антикорозійного захисту конструкцій.

Виконано посилення та ін’єкційного заповнення сухих тріщин, щілин і прихованих пустот та розшарувань й інших пошкоджень корозією балок і плит із застосуванням текучих поліуретанових композицій, що дало можливість продовжити ресурс експлуатації конструкцій.

Встановлено, що застосування системи Polymer Cement Concrete з використанням наклеєних композитних матеріалів забезпечило подальшу нормальну експлуатацію монолітного залізобетонного перекриття технічного поверху житлової будівлі.

Наведено рекомендації із проведення послідовності операцій при ремонті залізобетонних конструкцій будівель та споруд довготривалої експлуатації.

Ключові слова: бетонні та залізобетонні конструкції, деградація, корозія, дефекти, карбонізація бетону, арматура.

ДЕГРАДАЦИЯ БЕТОННЫХ И ЖЕЛЕЗОБЕТОННЫХ КОНСТРУКЦИЙ ЗДАНИЙ И СООРУЖЕНИЙ ДЛИТЕЛЬНОЙ ЭКСПЛУАТАЦИИ

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Аннотация. В работе на основе выполненных натурных исследований сформулированы проблемы деградации бетонных и железобетонных конструкций зданий и сооружений длительной эксплуатации и отмечена ее актуальность. Проанализированы авторами ряд работ по указанной проблеме. В частности, описаны результаты технической диагностики многих зданий и сооружений, как вновь построенных, так и длительной эксплуатации. Отмечена необходимость периодического проведения технической диагностики. На основании этих исследований обобщены основные факторы, значительно влияющие на снижение несущей способности железобетонных конструкций зданий и сооружений и установлено, что они сводятся к следующему: к ошибкам, допущенным при проектировании; к дефектам и недостаткам строительства; к недостаткам эксплуатации построек и сооружений.

Также, используя современные технологии и материалы, авторы определили преимущества их применения для ремонтно-восстановительных работ бетонных и железобетонных конструкций на ряде объектов длительной эксплуатации. По исследованиям и ремонтным работам сформулированы соответствующие выводы.

Установлено, что для предотвращения потери несущей способности конструкций долговременной эксплуатации нужно проводить исследования деградации и остаточного ресурса несущей способности конструкций, их надежности и долговечности, которые подвергались долговременному воздействию агрессивного воздействия воздушной, грунтовой и водной сред.

Установлено, что причиной снижения прочности бетона балок, эксплуатировавшийся в агрессивной среде, стало допущение ошибок в проектировании антикоррозионной защиты конструкций.

Выполнено усиление и инъекционное заполнение сухих трещин, щелей, скрытых пустот и расслоений и других повреждений коррозией балок и плит с применением текучих полиуретановых композиций, что позволило продолжить ресурс эксплуатации конструкций.

Установлено, что применение системы Polymer Cement Concrete с использованием наклеенных композитных материалов обеспечило нормальную эксплуатацию монолитного железобетонного перекрытия технического этажа жилого здания.

Представлены рекомендации по проведению последовательности операций при ремонте железобетонных конструкций зданий и сооружений долговременной эксплуатации.

Ключевые слова: бетонные и железобетонные конструкции, деградация, коррозия, дефекты, карбонизация бетона, арматура.

Стаття надійшла до редакції 15.01.2022