Збірник наукових праць. Галузеве машинобудування, будівництво
Academic journal. Industrial Machine Building, Civil Engineering
http://journals.nupp.edu.ua/znp
https://doi.org/10.26906/znp.2025.65.4180

UDC 624.016:624.073

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Experience in Strengthening Prefabricated Reinforced Concrete Floor Systems During the Rehabilitation of Industrial Buildings

Abstract. The article presents practical experience in combined reinforcing of precast reinforced-concrete beams and hollow-core floor panels during rehabilitation of an industrial building at the Chornomorsk Oil and Fat Plant. The initial technical condition of the structures and the results of the instrumental inspection have been described. The existing structure, consisting of long-span beams (up to 12 m) and hollow-core slabs (9 m spans), had suffered physical deterioration, exhibited excessive deflections, and required increased load-bearing capacity for design loads of 10–12 kPa. A proposed constructive-technological system combines: an external cage-truss rigid steel longitudinal reinforcement, increasing the cross-section by reinforced cast-in-place concrete topping, and creation of a monolithic slabs-beams joints. The design of mounting plates and cage-truss to beams joints using chemical anchors is detailed, it includes CBFEM analyses using IDEA StatiCa that demonstrate sufficient capacity and acceptable transfer of forces to the concrete. The procedure for topping the slab is given, including placement of reinforcement cages into the hollow cores, mesh reinforcement across the slab, and staged concreting. Advantages of the combined approach for increasing stiffness and load-bearing capacity and measures to limit local effects on existing sections are analyzed. Implementation results confirm the effectiveness of the proposed solution for restoration and enhancement of operational performance of large-span reinforced-concrete structures in industrial buildings.

Keywords: building rehabilitation; load-bearing capacity; reinforced-concrete floor system; increasing floor stiffness; chemical anchor; finite element method, technical condition, instrumental inspection.

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Received: 29.08.2025 Accepted: 11.09.2025 Published: 26.12.2025

Introduction.

Ensuring the operational serviceability of a building or structure for its entire design service life is a key objective of design, including from the standpoint of rational use of natural resources. To ensure the reliability of buildings and structures, it is necessary to prevent the physical deterioration of their structures, as well as to timely eliminate defects and damage identified during operation. The task of restoring the service life of industrial building structures – whose strength and deformability have been reduced due to both physical deterioration and damage from military actions – is urgent in Ukraine nowadays.

Furthermore, during reconstruction or restoration of buildings and structures there arises the need to improve their operational properties: increase load-bearing capacity and reduce deformability to achieve standards and design requirements. When providing not only structural restoration but also a significant improvement in the operational characteristics of buildings and structures, the term «sanation» [1] is used in scientific and practical literature.

Strengthening with external steel reinforcement and cross-section enlargement remain some of the main methods for restoring and enhancing the operational and strength characteristics of reinforced concrete span structures. Finding the optimal method for a reliable connection of existing structures with steel reinforcement (ensuring their composite action) is a crucial design task that arises when strengthening of reinforced concrete beams and slabs with external steel reinforcement and cross-section enlargement. An effective solution to this problem consists in simultaneously ensuring the compatibility of deformations of new and existing structures and limiting new local loads on existing structures at the force transfer places.

Review of the research sources and publications. Known methods for strengthening reinforced concrete hollow-core slabs include: 1 cross-section enlargement with reinforced cast-in-place topping and installation of vertical frames into the slab voids; 2) relieving steel beams installation from above with hangers in the joints between the slabs; 3) relieving steel beams instalation from below with wedging and mortar packing [1].

Known methods for strengthening reinforced concrete beams include: 4) cross-section enlargement with reinforced cast-in-place topping and installation of reinforcement cages; 5) additional main reinforcement bars installation by welding tem to the existing reinforcement through short bars; 6) truss tie rods with angle stops at the slab ends with tension nuts; 7) relieving steel beams installation from below with wedging and mortar packing; 8) reducing the span with steel outrigger supports on two-cantilever auxiliary beams; 9) composite slabs arrangment with changing the structural scheme, and others [1].

Thus, the composite action of existing floor elements and strengthening elements is achieved in these methods in various ways. Natural adhesion between existing and new concrete (methods 1, 4) is small and variable, increasing required design material to ensure contact-joint strength [3]. The use of welded connections (method 5) changes the properties of the existing reinforcement steel, which can be critical for prestressed structures. Welding to existing reinforcement (method 5) alters the properties of the existing steel and can be critical for prestressed elements. Mechanical anchoring and bearing (methods 2, 3, 6, 7) sometimes demand complex technology for lifting and aligning elements [4, 6].

The scientific search for improved strengthening solutions of span structures is aimed at developing the existing methods – optimizing redistribution of external loads [5], improving reinforced concrete jackets and side reinforcement [6], considering the actual elasto-plastic behavior of concrete [11] under the complex stress-strain states in strengthening structures [8, 9], and improving concrete properties [15]. Use of bolted connections for strengthening damaged reinforced concrete beams offers technological advantages in practice – as shown by [10, 12].

At the same time, chemical anchors [13, 14] are gaining popularity in modern construction practice for connecting steel and concrete structures, as they have a number of advantages over mechanical and friction anchors [2]. However, the experience of using chemical shear anchors in the rehabilitation of industrial buildings in Ukraine is limited and requires further research.

Problem statement. This paper describes the experience of combined strengthening of reinforced concrete beams and precast hollow-core slabs obtained during the scientific and technical support of the design and reconstruction of an industrial facility in Chornomorsk (Ukraine).

Main material and results. We present an example of an author's structural-technological solution for strengthening reinforced concrete beams and precast hollow-core panels of part of the slab above the basement during sanation of the production building of the Chornomorsk Oil and Fat Plant.

During the building's operation, the structure of this floor has undergone natural physical deterioration and does not meet current operational requirements. In particular, visual inspection revealed cracks in the floor, which occurred due to excessive deflections of the 9 m span hollow-core floor panels. Further inspection established the necessity of a major repair of the slab over the basement in the part of the building between the expansion joints in axes «9»-«22» / «Ж»-«Н» (Fig. 1) was established. At the same time, the modernization of production processes requires an increase in the maximum design live load on the floor: to an operational value of 10 kPa, and a limit value of 12 kPa.

The structural scheme of the building part for which precast reinforced concrete slab strengthening is designed differs for basement and first floor levels.

Below level 0.000 the building's structural system is a mixed frame-and-wall system with vertical load-bearing elements: outer monolithic reinforced concrete walls 600 mm thick and inner monolithic reinforced concrete columns with cantilevers, cross-section 600×600 mm, supporting a system of precast and cast-in-place ribbed reinforced-concrete slabs. Main precast beams have cross-section of 500×800 (h) mm with 12 m span and cross-section of 400×500 (h) mm with 6 m span; which support precast hollow-core panels with spans of 9 and 3 m and a height of 220 mm (larger part of the slab). Part of the floor slab (along the external monolithic reinforced concrete wall) is a cast-in-place slab 250 mm thick. Layout of hollow-core panels and cast-in-place slab above the basement is shown in Fig. 2a; beam layout in Fig. 2b. Loads are transferred to the soil base through a solid reinforced concrete foundation slab 700 mm thick. Spatial stiffness of this part of the building is ensured by the stiffness of the monolithic frame (foundation slab – columns – beams) working together with the floor slab formed by precast and cast-in-place panels.

Instrumental inspections established beam design details (Fig. 3). The edge beams with a section of 400x500(h) mm and a 6 m span have main longitudinal reinforcement of 4Ø25 mm in both the top and bottom zones along the entire length. The middle beams 500x800(h) mm with a 12 m span – 5Ø36 mm in both the top and bottom zones along the entire length. The spatial reinforcement cages of the beams are composed of individual flat cages, formed by connecting the longitudinal working reinforcement with transverse bars Ø12 mm at 200 mm spacing.

The floor topping thickness is 80 mm (50 mm over cast-in-place slab parts).

a) b)

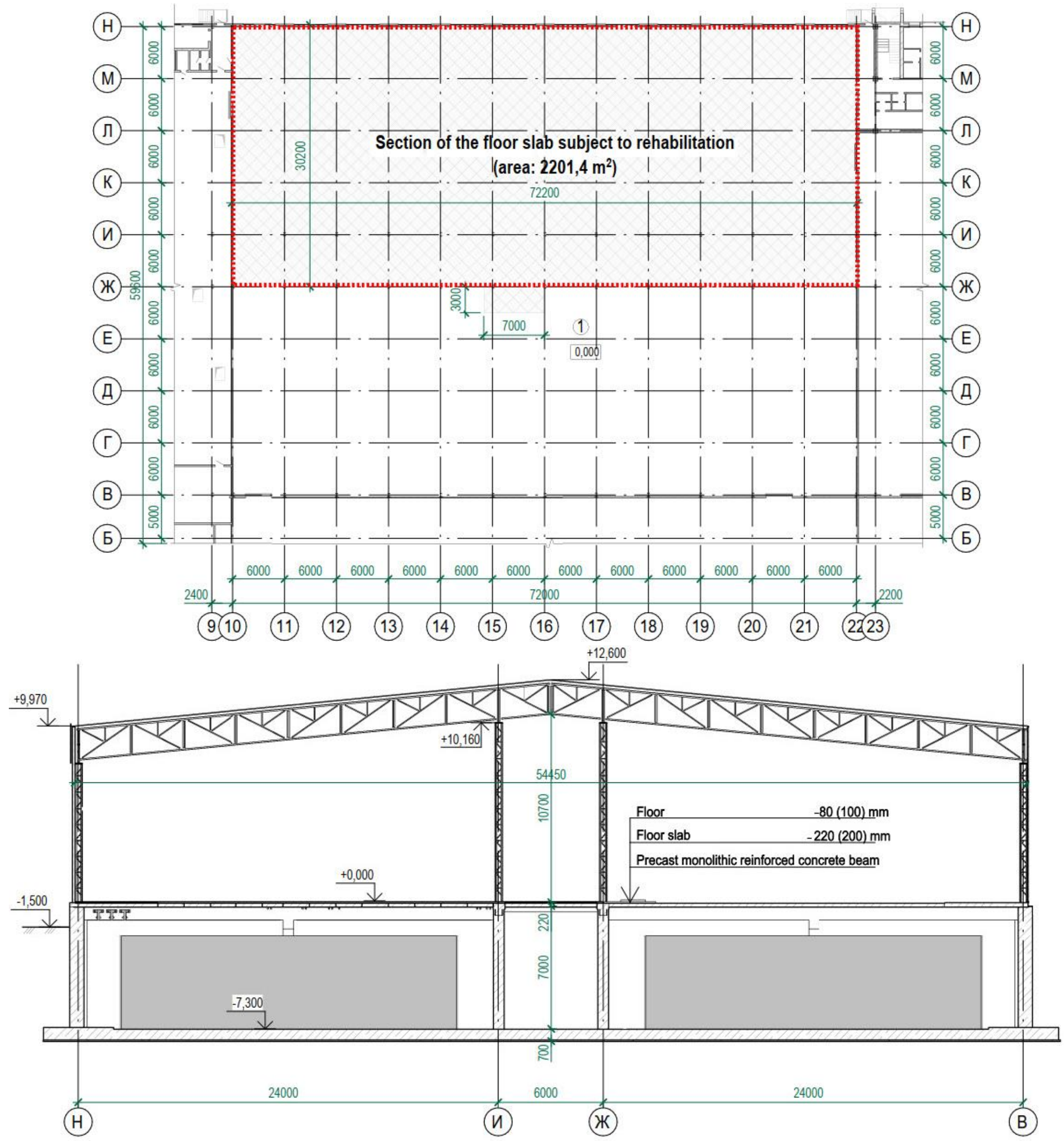


Figure 1 – Frame of the part of the building for which strengthening of the precast reinforced concrete floor is planned: *a* – first-floor plan (at the level of the floor being strengthened); *b* – cross-section

Interpretation of results and their approval.

To meet the design requirements, a combined strengthening system for the reinforced concrete beams and precast hollow-core floor slabs was developed. The load-bearing capacity and stiffness of the beams are increased by applying system of the following methods: a) installing additional external longitudinal rigid reinforcement; b) applying reinforced concrete topping to increase the cross-section by 340 mm; c) changing the beam cross-section from rectangular to T-shaped with a top flange (the precast slabs and cast-in-place topping become the beam's flange in their composite action); d) changing the beam's design scheme to continuous by creating a composite (precast-monolithic) section over the supports. A spatial view of a fragment of the strengthened floor is shown in Fig. 4. Fig. 5 shows principal detailing of the new floor slab after strengthening the existing structure. The design model of the strengthening mounting plate and the results of the finite element analysis are shown in Fig. 6.

The additional external longitudinal rigid reinforcement is made of rolled steel elements: in the tension zone 2∟125x10 S245; in the compression zone 2∟125x10 S245. They are combined into a welded spatial cage-truss jacket using vertical rigid reinforcement: ∟75x8 S245 and channels 16U and 12U. The stability of the cage-truss jackets compressed longitudinal elements is ensured by bracing along the length at max spacing 750 mm. Vertical reinforcement elements are connected to each other vertically through 12 mm thick mounting plates (Fig. 6). Welded joints allows for more effective redistribution of internal forces by absorbing part of bending moments and shear forces in the cage-truss jacket plane. Mounting plates will also absorb part of the shear forces and torsional moments in the beams (which are bending for the lattice element at this point).

An important aspect of the composite action of the reinforced concrete beam and the strengthening cage-truss jacket is the connection using chemical anchors, which are attached to the mounting plates. The positions for the chemical anchors attachment were determined based on their maximum proximity to the theoretical neutral axis at operational loads. It is impossible to place the plate directly in the zero-bending zone of the lattice elements due to the requirements for anchor bolt placement (minimum distances from the edge of the element and between anchors when checking for concrete breakout), as well as the need to minimize their impact on the stress-strain state of the reinforced concrete beam in the corresponding sections.

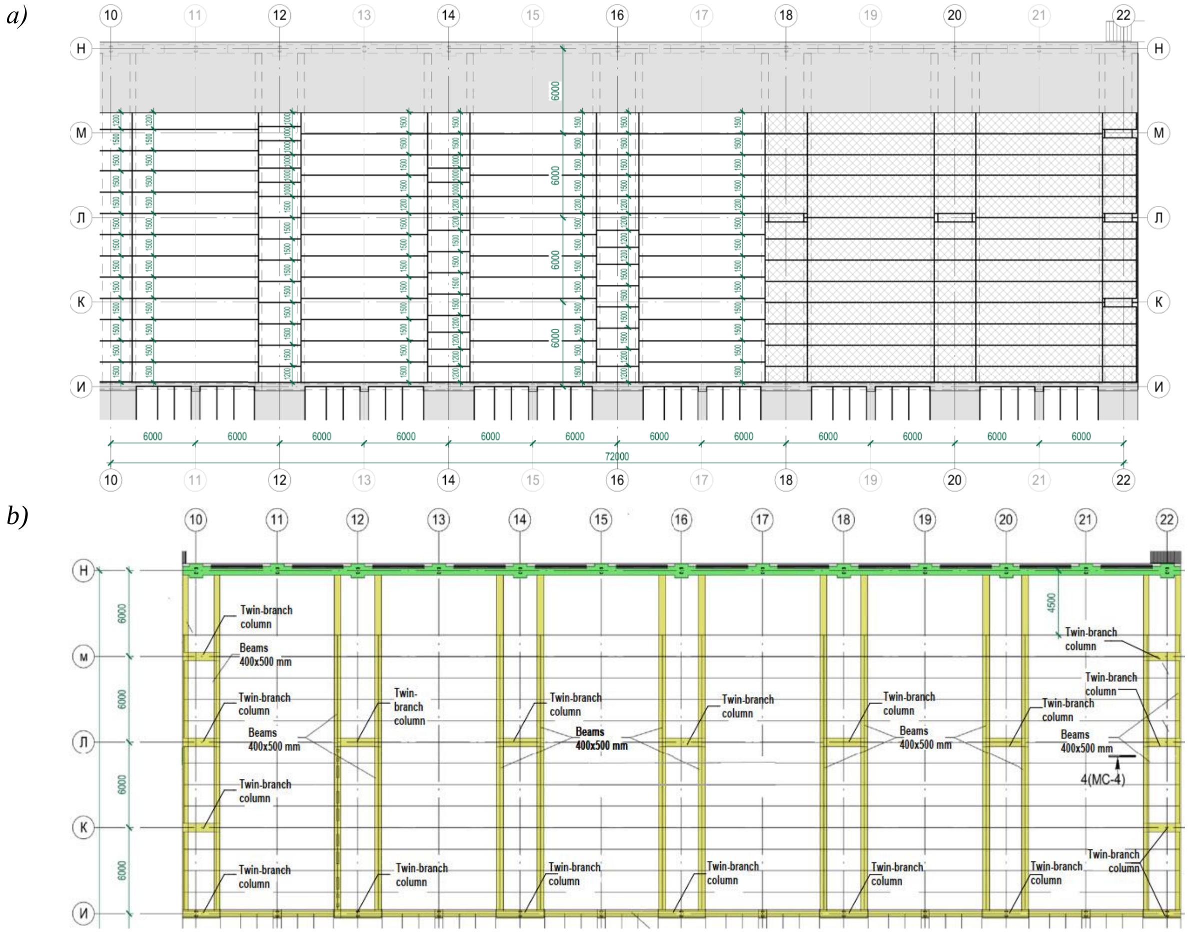


Figure 2 – Scheme of the floor elements above the building's basement: *a* – layout of hollow-core precast slab panels 90.12 and 30.12 and the cast-in-place slab; *b* – layout of the floor beams

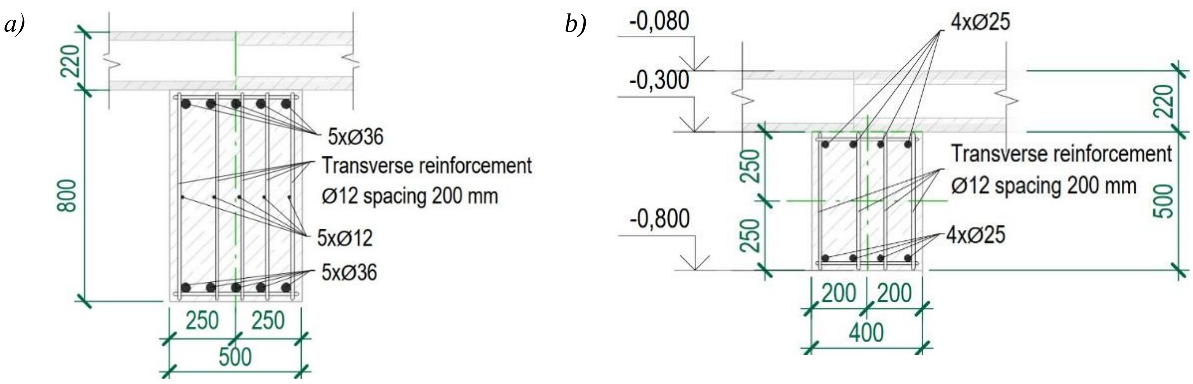
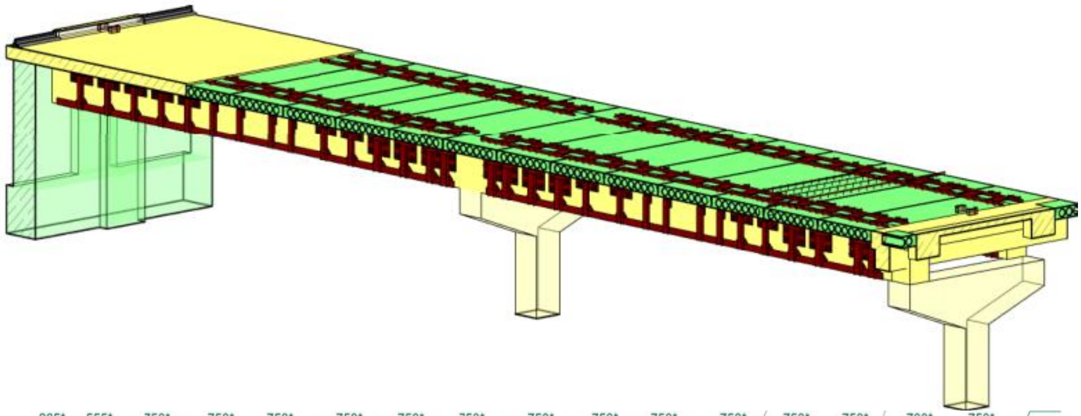


Figure 3 – Detailing of existing beams based on instrumental survey results:
***a* – 12 m span beam; *b* – 9 m span beam**

a)



b)

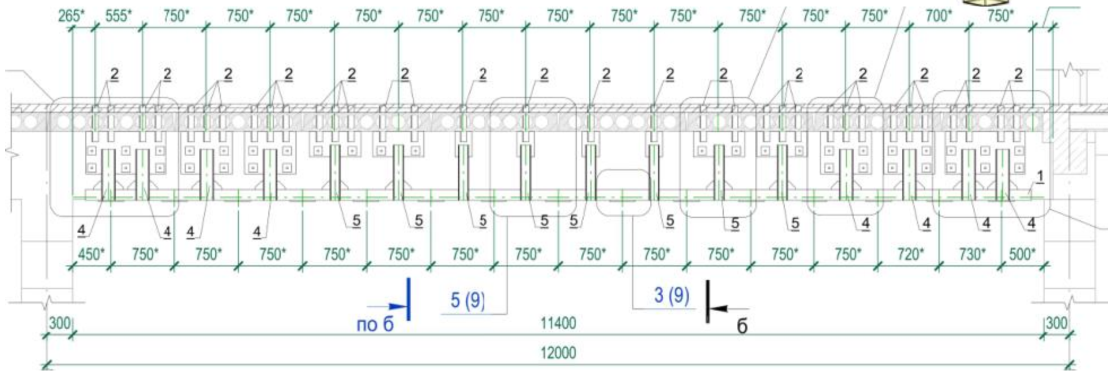
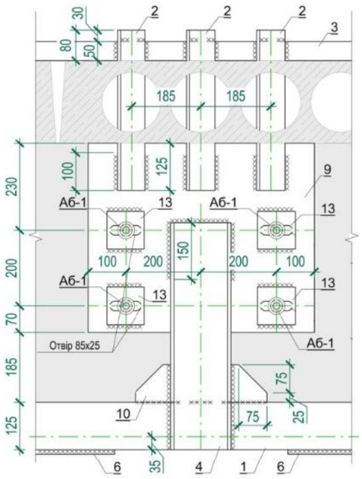
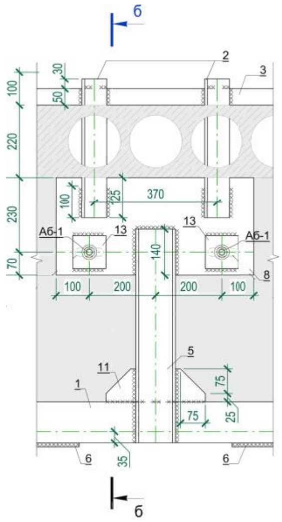


Figure 4 – Floor strengthening design: *a* – spatial view of a fragment of the strengthened floor structure; *b* – front projection of the strengthened beam

a)



b)



c)

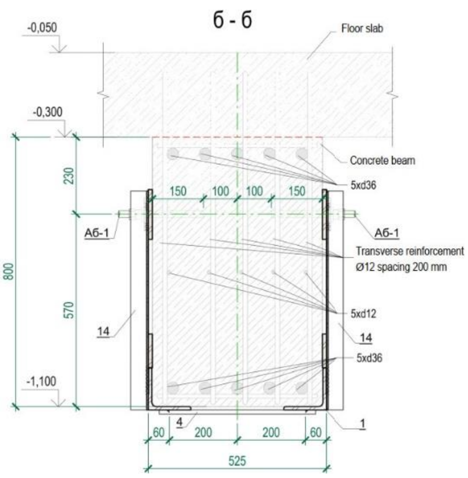
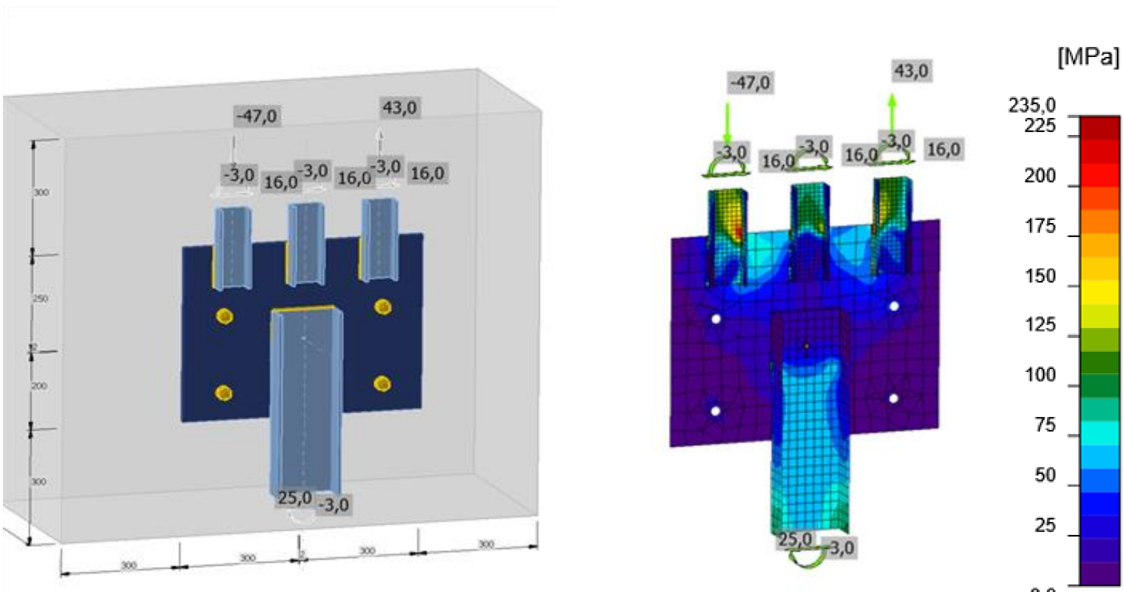


Figure 5 – Principal joints of beam strengthening details: *a* – support zone strengthening; *b* – span zone strengthening; *c* – cross-section of the strengthened beam; 1 – bottom rigid main reinforcement; 2, 4 – transverse reinforcement; 3 – top rigid main reinforcement; 8, 9 – mounting plates; 10 – corner plates to reduce connection pliability; 6 – bracing plates; Ab-1 – bolted connection of mounting plates with chemical anchors; 13 – cover plates for bolted connections



a) b)

Figure 6 – For the design of the mounting plate with four anchors: *a* – design (analytical) model; *b* – distribution of equivalent stresses in the element

Thus, the mounting plate operates under a complex stress-strain state. Its design used finite element method (FEM) calculations based on component-based modeling (CBFEM) with the IDEA StatiCa software package under the most unfavorable corresponding possible combinations of external loads (Fig. 6). Verification of bolted and welded connections was performed using the standard component method. The behavior of welds and bolts in the connections was modeled using linear elements. The actual stress-strain diagram for steel is replaced by a bilinear one. Stress in steel does not exceed the yield strength when using an ideal elasto-plastic stress-strain diagram.

The strength check of the chemical anchor connections was also performed using CBFEM in IDEA StatiCa (Fig. 7). The results of the anchor connection calculation are given in Table 1. Following assumptions were made: the mounting plate is not fixed relative to the beam concrete, welds are modeled using a special elasto-plastic element added between the plates, bolted joint consists of compressed plates and bolts working in shear and tension.

Modeling results indicate that instolled anchors ensure compatibility of deformations between strengthening cage-truss jacket and the existing reinforced concrete beam, with the anchors located closer to the middle of the beam span being the most loaded. Verification of the concrete according to DSTU EN 1992-4:2022 showed that the ultimate design stresses appear in concrete are about 50% of the corresponding values of the strength of C20/25 concrete.

To include the existing precast hollow-core panels in the composite action and, accordingly, to change the design cross-section of the existing rectangular beams to a T-section (with a flange in the upper composite slabs), concreting of the cores in the compressed zone (in the transverse direction for the slabs) is provided. The concrete class in all cases must not be lower than the actual concrete class of the existing structures.

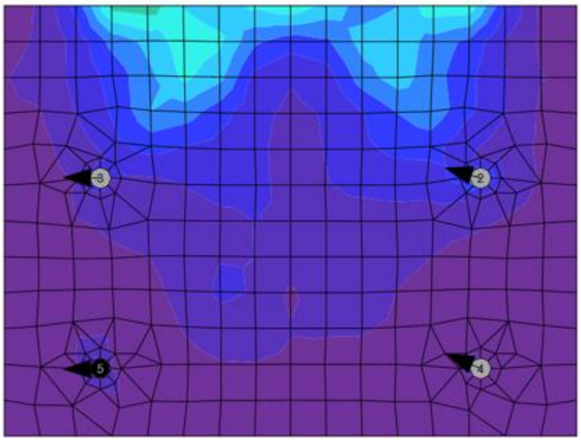


Figure 7 – Isofields of stresses in the plate and concrete in the anchor connection zone

Table 1 – Results of the anchor connection analysis

Anchor No	Ultimate external forces, kN		Concrete bearing capacity, kN	
	N_{Ed}	V_{Ed}	$N_{Rd,c}$	$V_{Rd,c}$
2	3,9	6,8	71,7	43,7
3	0,1	6,6	71,7	-
4	0,0	5,4	-	43,7
5	1,4	4,9	71,7	88,3

The reliability of the contact joint between the precast hollow-core slabs and the cast-in-place concrete slab topped above is ensured by the approved method of a shear key connection. A similar solution was adopted for strengthening the cast-in-place part of the existing slab. The cross-section enlargement was designed according to the following scheme: 1) installation of welded reinforcement cages with working reinforcement Ø12 A500C into pre-cut grooves in the panel cores; 2) reinforcement over the entire slab area with bars Ø12 A500C with a 200x200 mm mesh and additionally 3Ø25 A500C along the beams above the slabs; 3) joining all reinforcement elements using tying wire. Fig. 8 and Fig. 9 show diagrams of the stages of strengthening the floor panels by topping with a cast-in-place reinforced concrete slab.

Figure 10 shows photo documentation of the sequential stages of technological process for implementing the design solution proposed by the authors – from inspecting the technical condition of existing structures to installing the strengthening elements.

Conclusions.

An improved technological solution for strengthening long-span precast reinforced concrete beams and hollow-core panels has been implemented in the practice of industrial building rehabilitation. It is based on a combination of established methods for strengthening reinforced concrete structures and the use of chemical anchors in the connections between the strengthening elements and the existing structures to ensure their reliable composite action. The described experience supports recommending chemical anchors usage when restoration and significantly improve the operational characteristics of buildings and structures is required.

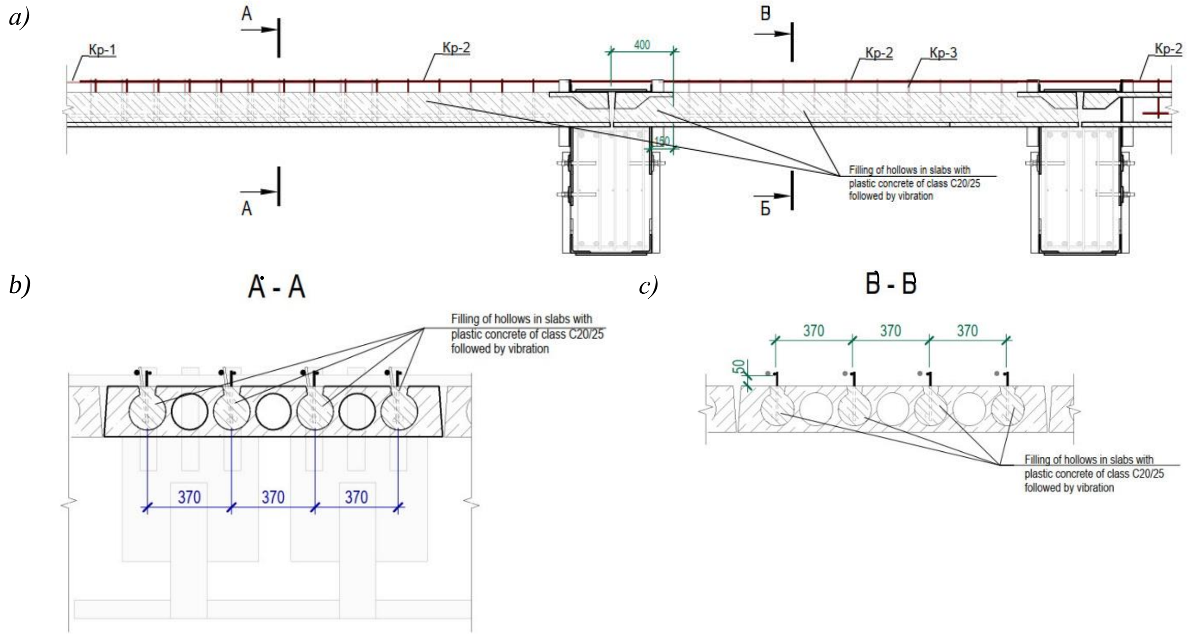


Figure 8 – Strengthening scheme for precast hollow-core panels: *a* – stage of installing additional reinforcement in the tension zone along the panels; *b* – section A-A for 9 m span panels; *c* – section B-B for 3 m span panels

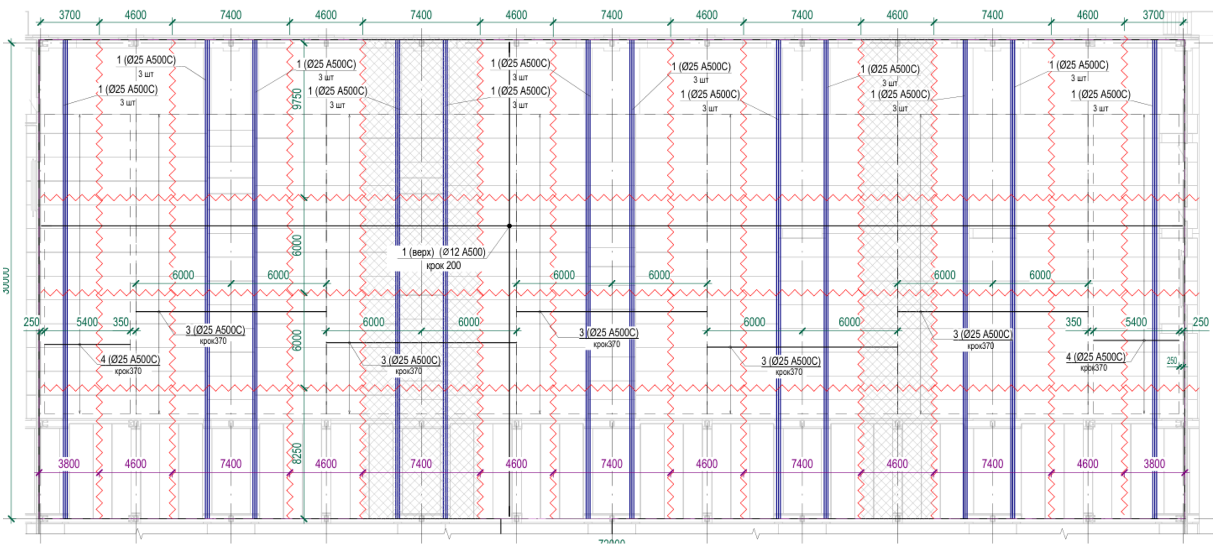


Figure 9 – Scheme of concreting sections (topping) of the floor slab above the precast slabs

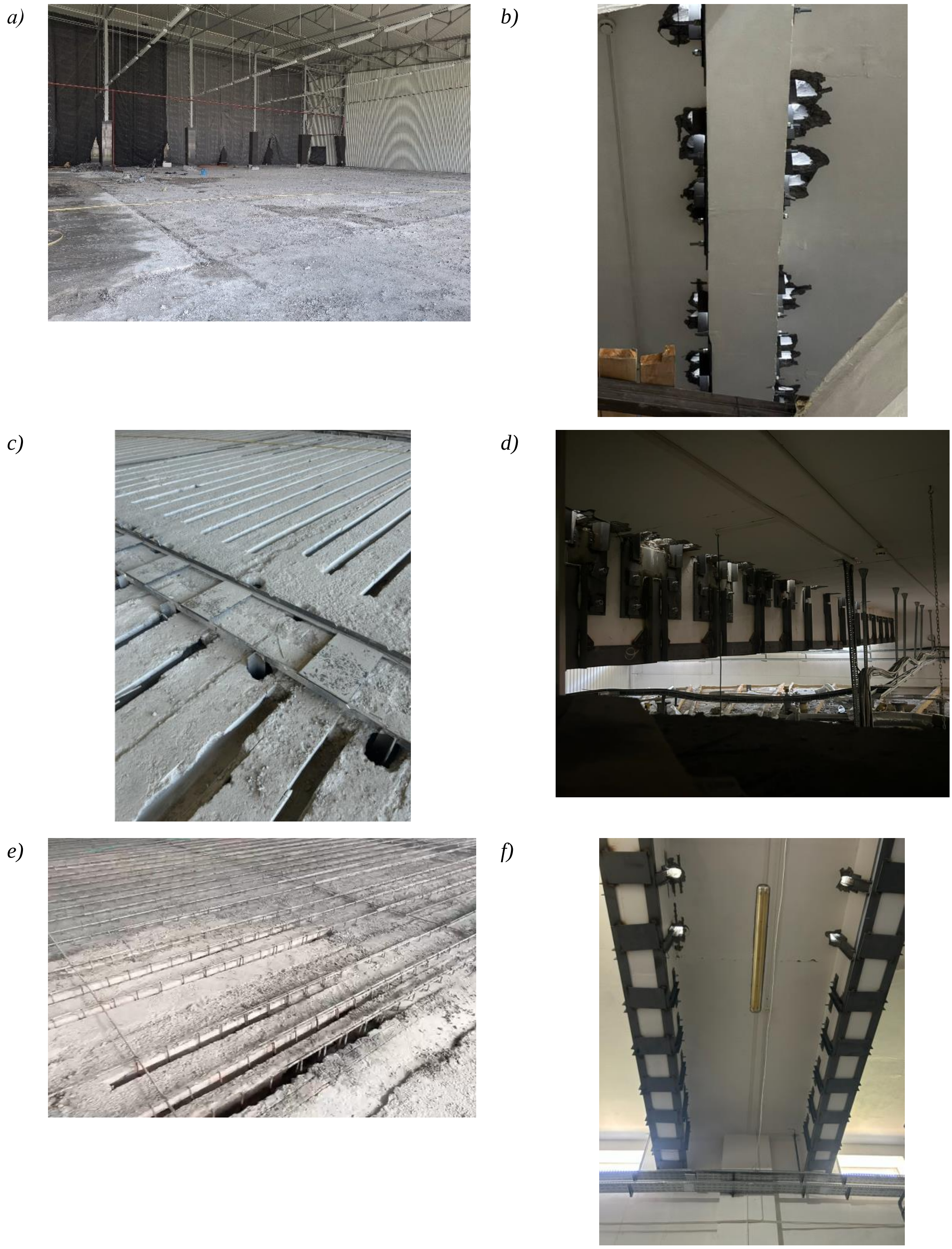


Figure 10 – Photos of different stages of floor strengthening: a – at the 1st-floor level before strengthening; b – openings for installing vertical stops; c – cutting grooves in the hollow-core panels; d – installation of metal cage-trusses with attachment to beams using chemical anchors; e – installation of reinforcement cages in the grooves and their concreting; f – finished structure of the strengthened beams (photo from below the floor from the basement level)

The proposed solution demonstrates high technological adaptability and can be effectively implemented not only in the rehabilitation of industrial facilities but also in civil construction, particularly in situations with limited access to structural elements or when complete dismantling is not feasible. The use of chemical anchors combined with traditional strengthening methods ensures enhanced reliability, reduces construction time, and minimizes intervention in the existing structural system.

References

1. Клименко, Є. В. (2010). *Технічний стан будівель і споруд* [Монографія]. Одеса: ОДАБА.

2. Золотова, Н. М., Скляров, В. О., Супрун, О. Ю., & Вихров, Д. М. (2019). Переваги використання хімічних анкерів на акрилових композиціях для кріплення технологічного устаткування. *Збірник наукових праць Українського державного університету залізничного транспорту*, (183), 87–95.

3. Романенко, Д. Б., & Душин, В. В. (2024). Аналіз роботи контактного шва між бетонами різних класів у згинаних залізобетонних елементах. *Вісник НУВГП. Серія: Технічні науки*, 1(45), 250–258. https://doi.org/10.31713/budres.v0i45.27

4. Semko, O., & Hasenko, A. V. (2021). Self-stressed steel-reinforced concrete floor slab stress–strain state numerical analysis taking into account the concreting stages. *IOP Conference Series: Materials Science and Engineering*, *1141*(1), Article 012043. https://doi.org/10.1088/1757-899X/1141/1/012043

5. Kitov, Y. P., Verevicheva, M. A., Vatulia, G. L., & Deryzemlia, S. V. (2018). Design solutions of optimal systems under action of dead and live mobile load. *Strength of Materials and Theory of Structures*, 100, 124–139.

6. Azizov, T., Melnik, O., & Myza, O. (2019). Strength and deformation of combined beams with side reinforced plates. *Materials Science Forum*, *968*, 234–239. https://doi.org/10.4028/www.scientific.net/MSF.968.234

7. Semko, O. V., & Hasenko, A. V. (2022). Classification of self-stressed steel–concrete composite structures. In *Proceedings of the 3rd International Conference on Building Innovations (ICBI 2022)* (Lecture Notes in Civil Engineering, Vol. 181, pp. 367–374). Springer. https://doi.org/10.1007/978-3-030-85043-2_34

8. Aidarov, S., Tošić, N., & de la Fuente, A. (2022). A limit state design approach for hybrid reinforced concrete column-supported flat slabs. *Structural Concrete, 23*, 3444–3464. https://doi.org/10.1002/suco.202100785

9. Galinska, T., Ovsii, D., & Ovsii, M. (2018). The combining technique of calculating the sections of reinforced concrete bending elements normal to its longitudinal axis, based on the deformation model. *International Journal of Engineering and Technology (UAE)*, *7*(3), 123–127. https://doi.org/10.14419/ijet.v7i3.2.14387

10. Wang, W., Zhang, X.-D., Zhou, X.-L., Wu, L., & Zhu, H.-J. (2021). Study on shear behavior of multi-bolt connectors for prefabricated steel–concrete composite beams. *Frontiers in Materials*, *8*, Article 625425. https://doi.org/10.3389/fmats.2021.625425

11. Pavlikov, A., & Harkava, O. (2020). Structural deformability of concrete. In *Concrete Structures for Resilient Society: Proceedings of the fib Symposium 2020* (pp. 519–525).

12. Karpiuk, I., Danilenko, D., Karpiuk, V., Danilenko, A., & Lyashenko, T. (2021). Bearing capacity of damaged reinforced concrete beams strengthened with metal casing. *Acta Polytechnica*, *61*(6), 703–721. https://doi.org/10.14311/AP.2021.61.0703

13. Cihan, M. T., Aydın, Z., & Kam, S. (2025). Tensile performance of inclined adhesive anchors in steel fiber-reinforced concrete. *Structural Concrete*. 26(5): 5936–5949. https://doi.org/10.1002/suco.202401103

1. Klymenko, Ye. V. (2010). *Technical condition of buildings and structures* [Monograph]. Odesa State Academy of Civil Engineering and Architecture.

2. Zolotova, N. M., Skliarov, V. O., Suprun, O. Yu., & Vykhrov, D. M. (2019). Advantages of using chemical anchors based on acrylic compositions for fastening technological equipment. *Collection of Scientific Works of the Ukrainian State University of Railway Transport*, (183), 87–95.

3. Romanenko, D. B., & Dushyn, V. V. (2024). Analysis of the performance of the contact joint between concretes of different classes in bent reinforced concrete elements. *Bulletin of the National University of Water and Environmental Engineering. Series: Technical Sciences*, 1(45), 250–258. https://doi.org/10.31713/budres.v0i45.27

4. Semko, O., & Hasenko, A. V. (2021). Self-stressed steel-reinforced concrete floor slab stress–strain state numerical analysis taking into account the concreting stages. *IOP Conference Series: Materials Science and Engineering*, *1141*(1), Article 012043. https://doi.org/10.1088/1757-899X/1141/1/012043

5. Kitov, Y. P., Verevicheva, M. A., Vatulia, G. L., & Deryzemlia, S. V. (2018). Design solutions of optimal systems under action of dead and live mobile load. *Strength of Materials and Theory of Structures*, 100, 124–139.

6. Azizov, T., Melnik, O., & Myza, O. (2019). Strength and deformation of combined beams with side reinforced plates. *Materials Science Forum*, *968*, 234–239. https://doi.org/10.4028/www.scientific.net/MSF.968.234

7. Semko, O. V., & Hasenko, A. V. (2022). Classification of self-stressed steel–concrete composite structures. In *Proceedings of the 3rd International Conference on Building Innovations (ICBI 2022)* (Lecture Notes in Civil Engineering, Vol. 181, pp. 367–374). Springer. https://doi.org/10.1007/978-3-030-85043-2_34

8. Aidarov, S., Tošić, N., & de la Fuente, A. (2022). A limit state design approach for hybrid reinforced concrete column-supported flat slabs. *Structural Concrete, 23*, 3444–3464. https://doi.org/10.1002/suco.202100785

9. Galinska, T., Ovsii, D., & Ovsii, M. (2018). The combining technique of calculating the sections of reinforced concrete bending elements normal to its longitudinal axis, based on the deformation model. *International Journal of Engineering and Technology (UAE)*, *7*(3), 123–127. https://doi.org/10.14419/ijet.v7i3.2.14387

10. Wang, W., Zhang, X.-D., Zhou, X.-L., Wu, L., & Zhu, H.-J. (2021). Study on shear behavior of multi-bolt connectors for prefabricated steel–concrete composite beams. *Frontiers in Materials*, *8*, Article 625425. https://doi.org/10.3389/fmats.2021.625425

11. Pavlikov, A., & Harkava, O. (2020). Structural deformability of concrete. In *Concrete Structures for Resilient Society: Proceedings of the fib Symposium 2020* (pp. 519–525).

12. Karpiuk, I., Danilenko, D., Karpiuk, V., Danilenko, A., & Lyashenko, T. (2021). Bearing capacity of damaged reinforced concrete beams strengthened with metal casing. *Acta Polytechnica*, *61*(6), 703–721. https://doi.org/10.14311/AP.2021.61.0703

13. Cihan, M. T., Aydın, Z., & Kam, S. (2025). Tensile performance of inclined adhesive anchors in steel fiber-reinforced concrete. *Structural Concrete*. 26(5): 5936–5949. https://doi.org/10.1002/suco.202401103

14. Zhou, D., & Yang, G. (2024). Chemical anchor bolts on concrete structures under combined tensile and shear loadings. *Structures*, *69*. 107580. https://doi.org/10.1016/j.istruc.2024.107580

15. Ngo, V. T., Lam, T. Q. K., Do, T. M. D., & Nguyen, T. C. (2019). Nano concrete aggregation with steel fibers: A problem to enhance the tensile strength of concrete. *E3S Web of Conferences*, *135*, Article 03001. https://doi.org/10.1051/e3sconf/201913503001

14. Zhou, D., & Yang, G. (2024). Chemical anchor bolts on concrete structures under combined tensile and shear loadings. *Structures*, *69*. 107580. https://doi.org/10.1016/j.istruc.2024.107580

15. Ngo, V. T., Lam, T. Q. K., Do, T. M. D., & Nguyen, T. C. (2019). Nano concrete aggregation with steel fibers: A problem to enhance the tensile strength of concrete. *E3S Web of Conferences*, *135*, Article 03001. https://doi.org/10.1051/e3sconf/201913503001

Suggested Citation:	
APA style	Marchenko, V., & Fedorov, D. (2025). Experience in Strengthening Prefabricated Reinforced Concrete Floor Systems During the Rehabilitation of Industrial Buildings. *Academic Journal Industrial Machine Building Civil Engineering*, *2*(65), 5-14. https://doi.org/10.26906/znp.2025.65.4180
DSTU style	Marchenko V., Fedorov D. Experience in Strengthening Prefabricated Reinforced Concrete Floor Systems During the Rehabilitation of Industrial Buildings. *Academic journal. Industrial Machine Building, Civil Engineering*. 2025. Vol. 65, iss. 2. P. 5–14. URL: https://doi.org/10.26906/znp.2025.65.4180.

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Досвід підсилення збірного залізобетонного перекриття при санації виробничих будівель

Аннотація. У статті представлено практичний досвід комбінованого підсилення збірних залізобетонних балок і багатопустотних панелей перекриття під час санації виробничої будівлі Чорноморського олійно-жирового комбінату. Описано вихідний технічний стан конструкцій, результати інструментального обстеження. Зокрема, існуюча конструкція, що складається з великопрогонових балок (до 12 м) та багатопустотних плит перекриття (прогоном 9 м), зазнала фізичного зносу, мала надмірні прогини. Проведено обґрунтування необхідності підсилення у зв'язку зі збільшенням розрахункових навантажень: до 10 кПа (експлуатаційне) і до 12 кПа (граничне). Запропоновано конструктивно-технологічну систему, що поєднує зовнішнє жорстке сталеве армування у вигляді ферми-обойми, нарощування перерізу армованим набетонуванням та забезпечення сумісної роботи плит і балок шляхом монолітного з'єднання. Детально описано конструкцію монтажних пластин і кріплення ферми до балок за допомогою хімічних анкерів з результатами CBFEM-розрахунків у ПК IDEA StatiCa, що підтверджують запас несучої здатності і жорсткості та прийнятну передачу зусиль на бетон. Наведено технологію нарощування плити зверху, включно з розміщенням арматурних каркасів у бороздах пустотних панелей і порядком бетонування захваток. Проаналізовано переваги комбінованого підходу щодо підвищення жорсткості та несучої здатності, а також обмеження локальних впливів на існуючі перерізи. Результати впровадження підтверджують ефективність запропонованого рішення для відновлення і підвищення експлуатаційних характеристик великопролітних залізобетонних конструкцій промислових будівель.

Ключові слова: санація будівель, несуча здатність, залізобетонна система перекриття, збільшення жорсткості перекриття, хімічний анкер; метод скінченних елементів, технічний стан, інструментальне обстеження.

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Надіслано до редакції:	29.08.2025	Прийнято до друку після рецензування:	11.09.2025	Опубліковано (оприлюднено):	26.12.2025