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HOLLOW BLOCK FLOOR'S SURVEY OF THE BUILDING OF THE EARLY 20TH CENTURY USING MODERN DIAGNOSTIC METHODS

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Summary. *The article provides the results of technical survey of the building of the beginning of the 20th century using modern non-destructive testing devices. The possible variants of the design of monolithic hollow floors are analyzed using different cavitation elements. The author determined the construction of the hollow prefabricated-monolithic floor of the building and the strength characteristics of its structural elements. The actual bearing capacity of the floor construction was calculated and the possibility of its further normal operation was established based on the data obtained during the instrumental surveys.*
Key words*: survey, diagnostics, non-destructive testing, hollow floor, ceramic floor blocks, integrity block and straw.*

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Problem setting. The question arises as to structural assessment, design reliability and possibility of their further use, repair or strengthening during reconstruction of buildings. These tasks may be solved using technical survey during which real bearing capacity and operational integrity of constructions and bases are defined. Very often constructions, which have to be surveyed, are nontypical and made according to individual project designs, which are difficult to find in modern literature. Calculations of such constructions can not be made according to modern design specifications. Such tasks should be solved individually using laboratories equipped with modern arrangement giving the possibility to survey such constructions right at the building object. The use of tools of non-destructive testing provides the opportunity to receive accurate information without specialized laboratories of destructive testing.

Review of recent investigations and papers. Reinforced concrete hollow floor is widely used in modern building. Constructive decisions of such floor and methods of their strengthening or reconstruction are widely investigated in modern literature [1]. However, the main part of such floor is made in collective version. Just recently, monolithic reinforced concrete hollow floor is started using [2]. Plastic embedded reservoirs are used as cavitation elements. Foam plastic and ceramic blocks and other things can be also used [3].

In practice, during testing buildings and constructions built 60 years ago, collective monolithic hollow floor was used, in which ceramic or integrity block and straw were used as cavitation elements. Bearing capacity and reliability of such floor without ruining its construction can be built using non-destructive testing methods.

Non-destructive testing methods on concrete strength were established during 1950-1960s in investigation of ultrasonic method made by I.M. Rabynovych, S.M. Sokolov, Yu.A. Nilender, M.A. Novhorodskyy, I.A. Dykovskyy and A.I. Kravtsov. Non-destructive testing methods were described in scientific works by B.H. Skramtayeva and M.Yu. Lishchynskyy "Concrete strength testing" (M., 1964) and in scientific investigations made by M.H. Korevytska "Non-destructive testing methods of reinforced concrete constructions" (M., 1989). Benefits and drawbacks of different non-destructive testing methods on concrete strength were investigated by the following Ukrainian scholars: O.M. Pshinko, V.P. Lysnyak, A.M. Zinkevych, H.M. Hladyshev, D.H. Hladyshev, M.A. Chernukha, V.P. Ovchar and the following Russian scholars: A.V. Ulybin, S.D. Fedotov, D.S. Tarasova,

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M.V. Vorontsova, A.A. Vasylyev [4].

Research objectives. Intermediate floor of the building (Chortkiv, Ternopil Region) has been investigated using non-destructive testing methods to define its reliability and possibility of further secure use after reconstruction for multi-purpose building.

Problem definition. Based on investigation of archive documents, it was defined that the building was built during 1937 – 1938. There was no control of the use of this building for many years. The territory of the object belongs to the fourth region of snow load S_0=1400 Pa and wind load W_0=550 Pa, true and not melted one [5]. According to the map ЗСР-2004-А and appendix А ДБН В.1.1-12-2014 [6] seismicity of the territory is 6 grades. According to (state standard of Ukraine) DSTU-Н Б В.1.2-16:2013 [7, 8] the object of reconstruction belongs to the group of consequences (responsibility) СС2 and to the third category of complexity.

Construction project is three-, four- and five-storied T-shaped complex building according to plan (Fig. 1). Constructive form of the building is wall with load-bearing exterior and interior walls. House footing is band and monolithic reinforced concrete slab. The floor above the basement floor is monolithic reinforced concrete beam; the interfloor was made from hollow ceramic and integrity block and straw. The roof of the building is tent, wooden and gable; covering was made from zinc-plated metal and asbestos-cement wavy boards.

Figure 1. Exterior of the building (Chortkiv, Ternopil Region)

According to the results of previous technical survey of the building, it was identified that the construction of the footing, exterior and interior load-bearing walls, walls, constructions of the floor above the basement floor, constructions of the stairs are in good technical condition and reliable, and secure for further use. The constructions of the roof and covering, floor, windows and doors are in unsatisfied technical condition and should be changed. Intermediate floor made from hollow ceramic and integrity block and straw should be surveyed, the type of construction should be defined, the retained strength of the materials should be investigated using non-destructive testing methods. The task is to calculate and define the factual bearing capacity of the floor after its long use on the base of the received data.

Testing methods. The surveys were made by Scientific-testing laboratory of building materials, production and constructions at Ivan Pulyuy Ternopil National Technical University (Certificate № РХ-1348/14) [9].

Instruments of non-destructive testing methods were used to test concrete strength, ceramic blocks, and control of arrangement and diameter of fittings during the investigation. The thickness of protective cover of concrete, arrangement and diameter of fittings on test areas were defined using the magnetic method according to (state standard of Ukraine) DSTU Б В.2.6-4-95 [10]. Characteristic of concrete strength and ceramic blocks of the floor was defined using the method of shock pulse according to (state standard of Ukraine) DSTU Б В.2.7-220:2009 [11].

Testing using shock pulse was made according to the following sequence:

- dependence detection between material strength and indirect strength characteristic;
- building of calibration dependence;
- surface cleaning of a production on test areas;
- fixation of the meaning of direct strength characteristic.

Facilities for testing and measuring devices used during testing of the object are shown in Table 1.

Table 1

Measuring device

№	Name of device or arrangement	Measuring border	Accuracy class or error of measuring device	Date of the next review, test
1	Electronic measure of concrete strength ИПС-МГ 4.03, serial number 6812	*3-100 MPa*	*±8 %*	*06.2017*
2	Electronic measure of protective cover of concrete and arrangement of fittings ИПА-МГ4, serial number 1803	*0-150 mm*	*±10 mm*	*06.2017*

Research results. Two floor areas on the ground floor and one floor area on the first floor of the building were surveyed according to technical task. At first test area, the construction and material strength of prefabricated-monolithic floor were investigated on the ground floor (Fig. 2, 3). At the second area, the construction and material strength of the load-bearing composite steel and concrete floor beam of the floor were investigated on the ground floor (Fig. 4). At the third area, the construction and material strength of prefabricated-monolithic floor were investigated on the first floor (Fig. 5).

Figure 2. Area “1” Bottom view of hollow block floor on the ground floor

Figure 3. Area “1” Dismantling of bottom surface of hollow block floor on the ground floor

Figure 4. Area “2” Location of an instrumental survey

Figure 5. Area “3” Construction of hollow block floor on the first floor

Dismantling of bottom surface of the floor for more detailed survey of the construction was done after investigations of protective cover thickness of concrete, arrangement and diameter of fittings using magnetic method at the first test area (Fig. 3). Having made visual examination and measuring works, geometrical size and construction of prefabricated-monolithic floor 260 mm in thickness were defined and shown in Fig. 6.

The floor consists of ceramic hollow trapeziform in cross-cut blocks 305×250×210 mm in size, which are located in lines along floor bay l=6.5 m (Fig. 2). Soft reinforcing bar 22 mm in diameter is located between each line of blocks. The space between ceramic blocks is filled with monolithic concrete. Solid monolithic plate 40 mm in thickness, which was reinforced using mesh 6 mm in diameter with space 300×300 mm, was filled above blocks.

During instrumental survey, it was determined that concrete in ribs of construction of prefabricated-monolithic floor is insufficiently compressed, as evidenced by hollows and bared fittings, which are partly not covered by concrete at the bottom (Fig. 3). Insignificant corrosion was found at the fittings, which does not cause its decay.

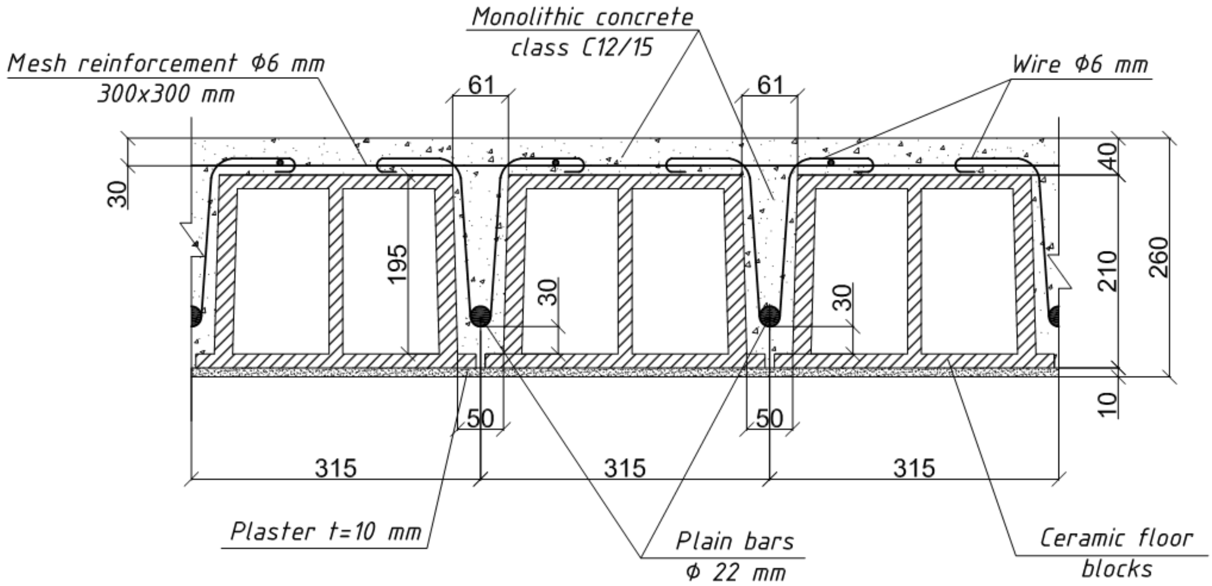

Figure 6. Construction of hollow block floor on the ground floor

The results of measurements of cubical concrete strength and strength of ceramic floor blocks on the ground floor using the method of shock pulse according to (state standard of Ukraine) DSTU Б В.2.7-220:2009 is shown in Table 2 (area №1).

Table 2

The results of measurements of cubical concrete strength and strength of ceramic floor blocks

№ area	Name of material	Indication of instrument				Average strength, MPa
		1	2	3	4	
1	Concrete	16.7	15.8	16.2	15.6	**16.1**
	Ceramic block	10.8	9.9	10.0	10.5	**10.3**
2	Concrete	8.8	8.7	9.6	9.2	**9.1**
3	Concrete	10.6	11.3	9.6	10.5	**10.5**

According conducted technical survey of hollow block floor on the ground floor using the method of shock pulse, cubical concrete strength is 16.1 MPa what is correspondent to the strength class of concrete C 12/15 with statistic security 0.95 according to state building norms of Ukraine ДБН В.2.6-98:2009 [12]. Strength of ceramic blocks of hollow block floor on the ground floor is 10.3 MPa that corresponds to the grade M100 according to state building norms of Ukraine ДБН Б В.2.7-61:2008 [13].

Having done technical survey and measurements of bearing composite steel and concrete floor beam on the ground floor *l*=4.2 m in span, its geometrical size and construction were determined, which are shown in Fig. 7. The beam is 440×420 mm in size and consists of three metal l-beams 230 mm in height and its shelf is 12 mm in thickness, which are embedded (Fig. 4). There is insignificant corrosion on the surface of l-beams, which does not cause their decay.

The results of measurements of cubical concrete strength of bearing composite steel and concrete floor beam on the ground floor using the method of shock pulse according to (state standard of Ukraine) DSTU Б В.2.7-220:2009 are shown in Table 2 (area №2). According to conducted technical survey, the cubical concrete strength of the beam is 9.1 MPa, which is less than minimal class of strength of concrete C 8/10 with statistic security 0.95 according to state building standards B.2.6-98:2009.

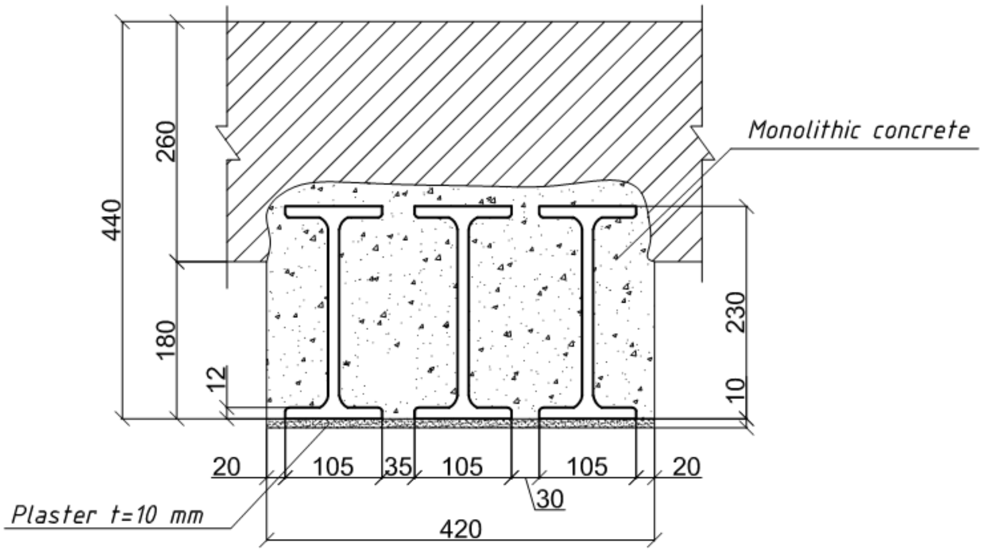

Figure 7. Construction of the load-bearing composite steel and concrete floor beam on the ground floor

Geometrical size and constructions of composite monolithic floor is 210 mm in thickness on the first floor (Fig. 5), determined during technical survey, are shown in Fig. 8. The floor consists of integrity block and straw 400×400×170 mm in size with right-angled cross cut, which is located in lines along floor bay *l*=5.5 m. Soft reinforced bar 24 mm in diameter is located between each line of blocks. The space between integrity block and straw is filled with monolithic concrete. Solid monolithic floor 35 mm in thickness was filled above blocks.

Conducting technical survey, it has been determined that concrete in the ribs of the construction of prefabricated-monolithic floor is heterogeneous and insufficiently compressed, as it is evidenced by availability of hollows and baring fittings (Fig. 5). Insignificant reddening caused by corrosion, which does not cause its decay, was found on the fittings.

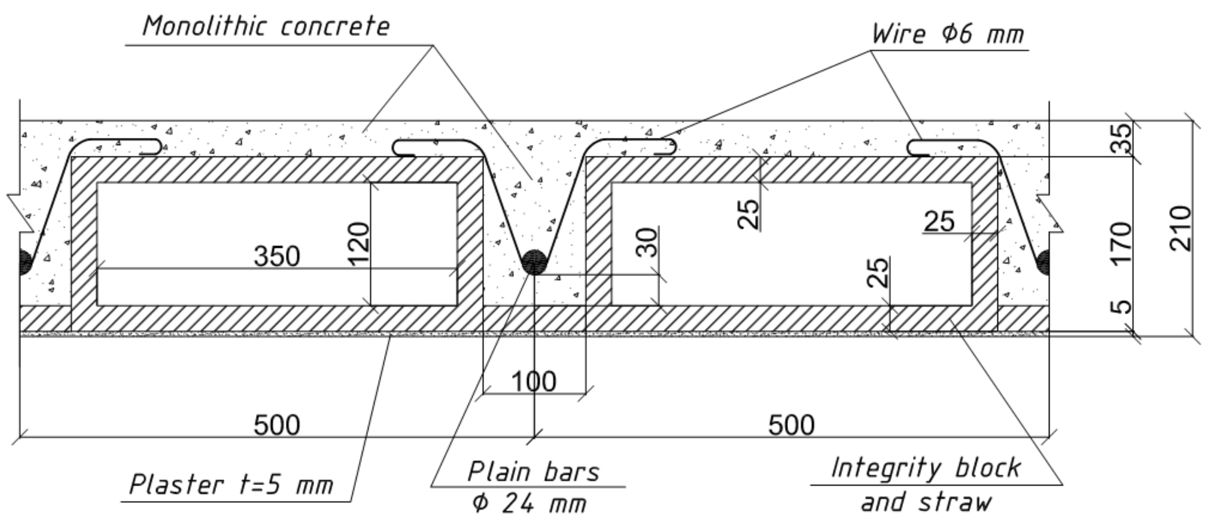

Figure 8. Construction of hollow block floor on the first floor

The results of measurements of cubical concrete strength of hollow block floor on the first floor using the method of shock pulse according to (state standard of Ukraine) DSTU Б В.2.7-220:2009 are shown in Table 2 (area №3). According to conducted technical survey, cubical concrete strength is 10.5 MPa what is less than minimal class of concrete strength С 8/10 with statistic security 0.95 according to state building standards of Ukraine В.2.6-98:2009.

All necessary data were received on the base of technical survey to calculate factual bearing capacity of the main bearing floor constructions on the ground floor and on the first floor. The results of such calculations are shown in Table 3.

Table 3

Results of calculations of the actual bearing capacity of the floor construction

№ area	Name of construction	Factual bearing capacity	Bearing capacity of modern constructions-analogues
1	Composite steel and concrete floor beam on the ground floor	8.55 t/m.l.	8.55 t/m.l.
2	Prefabricated-monolithic floor on the ground floor	0.406 t/m^2	0.800 t/m^2
3	Prefabricated-monolithic floor on the first floor	0.323 t/m^2	0.800 t/m^2

Indications of bearing capacity of modern constructions similar to investigated ones were shown in the last column in Table 3. As it is shown in the table, only load-bearing capacity of composite steel and concrete floor beam on the ground floor is correspondent to specified requirements. Load-bearing capacity of prefabricated-monolithic floor on the ground floor and on the first floor is two times less than it is necessary. Therefore, during reconstruction it is necessary to use measures to increase bearing capacity of such floor. Owing to quite factual remaining bearing capacity of these floors during their reconstruction, they can be remained as unmovable decking and new monolithic floor can be done.

Conclusions. In practice of technical survey of buildings and constructions used during a long period of time, untypical constructions, which should be individually examined as to their diagnostics, calculation of factual bearing capacity and reliability of further use can be found. Investigating such type of constructions, study of the history of the development of project decisions and methods of their use in buildings during construction is important. It happens that to get any information about peculiarities of making some constructions is impossible. In such case, it is necessary to use modern methods and means of diagnostics of technical condition of constructions, in particular non-destructive testing methods. The use of devices of such type allows getting accurate result at the building project. The use of such movable laboratories allows simplifying, making cheaper and making tasks easer for technical experts and allows making quick decisions concerning further renewing, strengthening or changing of constructions. Investigated object in this article is unique in its construction, the useful life of a building and possibility for further use. However, the floor construction, investigated in details and calculated in this work, without change of functional profile of the building could be used for a long time. Owing to accurate factual remaining bearing capacity of this floor during its reconstruction, it can be remained as unmovable decking and new monolithic floor can be done.

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ОБСТЕЖЕННЯ ЗБІРНО-МОНОЛІТНОГО ПЕРЕКРИТТЯ БУДІВЛІ ПОЧАТКУ ХХ СТ. ІЗ ЗАСТОСУВАННЯМ СУЧАСНИХ МЕТОДІВ ДІАГНОСТИКИ

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Резюме. *Наведено результати технічного обстеження будівлі початку ХХ ст. із використанням сучасних приладів неруйнівного контролю. Проаналізовано можливі варіанти проектування монолітних порожнинних перекриттів із застосуванням різних порожниноутворюючих елементів. Визначено конструкцію порожнинного збірно-монолітного перекриття будівлі та міцнісні характеристики його конструктивних елементів. На основі даних, отриманих у ході інструментальних випробувань, проведено розрахунок фактичної несучої здатності перекриття та встановлено можливість його подальшої нормальної експлуатації.*

Ключові слова: *обстеження, діагностика, неруйнівний контроль, порожнинне перекриття, керамічні блоки, цементно-солом'яні блоки.*

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