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SIMPLIFIED NON-DESTRUCTIVE METHOD FOR DETERMINING THE INTEGRITY OF HOLLOW-CORE SLABS

[1]**Murashko O.V.**, Doctor of Engineering Science, Associate Professor,
alexeymurashko@gmail.com, ORCID: 0000-0002-2812-5951
[2]**Kalinichenko A.S.,**
kb2a.precast@gmail.com, ORCID: 0000-0001-9237-4218
[2]**Stebelsky A.L.,**
stebelsky.budova@ukr, ORCID: 0000-0002-0321-478X
[3]**Kubiiovych M.I.,**
kubiyovych_m@ukr.net, ORCID: 0000-0002-8500-032X
[1]**Voloshchuk V.V.**, graduate student,
vadims9292@gmail.com, ORCID: 0000-0001-6259-7090
[1]*Odesa State Academy of Civil Engineering and Architecture*
4, street Didrichson, Odesa, 65029, Ukraine,
[2]*Collective enterprise «Budova»*
25, street Osipova, Odesa, 65012, Ukraine,
[3]*Private enterprise «Kapitel-M»*
8-B, street Armiyska, office 8, Odesa, 650058, Ukraine,

Abstract. The article presents the results of analysis of reinforced concrete hollow-core prestressed bench non-formwork molding floor slabs, manufactured using extrusion technology for defects formed as a result of a combination of a number of climatic effects during the construction of the building. The appearance of this kind of defects is quite common in construction practice. The issues of eliminating the causes of such defects, as well as strengthening damaged ceilings, are not the subject of this study.

The purpose of the analysis was to identify damage to concrete and damage to the integrity of the slab ribs, which are not always available during visual screening. Existing methods of non-destructive testing with the help of specialized equipment make it possible to determine the strength of concrete as well as the presence of cracks and their configuration in products. The disadvantages of such methods include: high cost of equipment, the necessary level of qualification of specialists using it and the impossibility of its use for mass verification of the integrity of slabs.

Therefore, it became necessary to develop a method for detecting defects in prefabricated structures for prompt inspection at the construction site. The proposed method makes it possible to quickly check the presence of significant defects in the construction due to sound audible analysis from strikes by a hammer on the slab. The simplified method of determining the integrity of hollow-core slabs makes it possible to narrow the volume of thorough and time-consuming instrumental studies during a complete inspection of the object, allocating places that need a thorough examination of damaged areas of structures from the total volume of prefabricated slabs of the object.

According to the results of the research, it was determined that sound can be divided into three main types that characterize the nature of the structure defect: voiced sound indicates that the structure is not damaged, thud sound - the structure is damaged by near cracks, intermediate sound - the structure has deep cracks, mainly in a vertical rib.

Keywords: reinforced concrete hollow-core prestressed prefabricated slabs, crack, concrete, control method, sound, defect.

Introduction. The problem of damage to hollow-core slabs today is quite relevant. The analysis of world experience indicates the expediency of using prefabricated hollow slabs made by extrusion technology. These designs have reached a very widespread. The use of such structures leads to significant savings in reinforcement and concrete, due to the use of preliminary stress, and

the formation of voids.

But like all structures, prefabricated hollow slabs made by extrusion technology have their "Achilles heel". During construction, when the slabs are exposed to atmospheric influences, they absorb water from precipitation. With the combination of several climatic phenomena, this moisture accumulates in a significant amount inside the voids, turns into ice and causes structural defects. This absorbed water tends to accumulate inside the voids mainly between the monolithic areas or lifting loops. For typical slabs with a bend up in the middle of the span, water will tend to flow to the ends, and after freezing, chip off the shelves of slabs (there are a number of structural and technological measures to prevent such defects). Our group faced this problem when was analyzing the damage of floor slabs during the construction of the building (Fig. 1, Fig. 2).

Fig. 1. Destruction in the upper part of the slab

Analysis of research and publications. In the literary analysis course, were considered methods of non-destructive testing. Today, methods of non-destructive testing of strength and integrity of reinforced concrete structures are widely used. The most common methods are elastic rebound and shock pulse. These methods with the help of specialized rather expensive equipment make it possible to determine the strength of concrete. But for the situation in question, the use of such equipment is not advisable because detached layers of concrete have design strength. Therefore, it is advisable to use methods of ultrasonic defectoscopy. It is this method that allows you to determine the presence of cracks and even build a three-dimensional crack surface. But the disadvantages of this method include: the high cost of equipment, the required level of qualification of specialists using it, and the impossibility of its use for mass testing of the integrity of slabs.

So, it is necessary to develop a simplified method for determining the integrity of hollow – core slabs, which would allow mass inspection of products, at the output, input control, and after installation.

It should be noted that in parallel with officially classified methods for determining the strength of concrete on construction sites, other – simplified methods are used. For example, analysis of the depth of the trace on the surface from a metal object, from a chisel and a hammer, or only a hammer. For monolithic structures, such approaches provide an opportunity to obtain a qualitative characteristic of the condition of concrete. In some cases, when was using concrete C15/20, C20/25 in the depth of the trace on the surface, experienced specialists can visually determine the strength with an accuracy of 50-100 kgf/cm^2. But in the case where this article is devoted, extrusion molding slabs from concrete are used C30/35, so trace of impact on the surface of concrete is difficult to differentiate visually. The development of such simplified methods is a promising problem that can significantly simplify the procedure for assessing the bearing capacity and quality of structures [1-3].

Fig. 2. Destruction in the lower part of the slab

The purpose of the work is to modify the existing non-destructive method of determining the quality of prefabricated reinforced concrete pre-stressed floor slabs for detection and localization of hidden defects. The object of study is damaged prefabricated hollow-core pre-stressed extrusion molding slabs. The subject of the study is a non-destructive method for detecting damage in prefabricated hollow pre-stressed extrusion molding slabs.

Materials and methods of research. Such deformations of floor slabs are quite common around the world, where in the construction of buildings using such structures, locking can occur with subsequent freezing (Fig. 3) [4, 5].

The problem determined in the course of the analysis of both foreign and own research indicates the probability of cracks not only in shelves, but also in the ribs of the floor slabs (Fig. 4), which cannot be detected visually at the input control at the construction site [6-10]. Such cracks can significantly affect the bearing capacity of the slabs. Therefore, a simplified technique is necessary that would allow to detect the presence of cracks in hollow slabs of floors.

Fig. 3. Typical chipping of the lower shelf of the plate due to the expansion of the ice
the USA, Maryland

Results of the study. During the examination of a number of floor slabs, our group has been used a hammer, which in detecting damage in the form of detached layers beated off damaged areas of concrete. After beating off the layers, the contours of damage became open for inspection (Fig. 5., red chalk circled a section of damaged concrete to be dismantled). The hammer was used to reflect the peeled concrete in the upper and lower parts of the slabs. During the beating off, the boundaries of the

damaged and intact fragment of the structure were easily determined due to the fact that the sound was significantly different: when hitting the damaged concrete, the sound was thud, and the sound was voiced on the intact concrete. In further studies and detection of damage of the ribs between the voids, a third – intermediate type of sound was identified, while the visual indications of the presence of damage were absent, both during the inspection of the lower surface and during the inspection of the upper surface, the hair cracks along the joints of the floor slabs were also absent.

Fig. 4. A crack that appeared in the rib between the cavities

The proposed method allows to determine areas where it is possible to perform a detailed analysis of damages using ultrasonic defectoscopy. Also, this method allows you to determine the boundaries of the area of damaged concrete to be dismantled.

With the help of sound analysis in beats, it is proposed to carry out incoming control, and control the state of hollow-core slabs of floors after closing the outer contour of buildings.

It should be noted that in the study of intact hollow-core slabs from beats on the ribs and voids sound was uniform**.**

Fig. 5. Contours of damage after reflection of exfoliated surface layers

Conclusions. The results of the research showed that**:**

1. Analysis of ceiling slabs of reinforced concrete pre-stressed bench non-forming with defects obtained due to the effects of combinations of climatic factors revealed the probability of formation of surface detachments of concrete, and violation of integrity not only in the level of the protective layer, but also in ribs that cannot be detected during visual control.

2. Existing methods of nondestructive testing allow to detect such defects quite accurately, but require a lot of time and cannot be used for mass control and inspection at the construction site.

3. The proposed method allows you to check the presence of cracks in concrete by analyzing the sound from hammer strikes, which can be divided into three types, which can indirectly indicate the state of the structures: voiced sound – the design is intact, thud sound – the structure is damaged by cracks of the near occurrence, intermediate sound – the design is damaged by deep cracks.

References

[1] O. Murashko, I. Benradi, "Analysis of world experience in the field of rapid visual screen", *Visnyk Odeskoi derzhavnoi akademii budivnytstva ta arkhitektury*, no. 58, pp. 275–282, 2015.

[2] O. Murashko, O. Adamov, "A New Approach To The Dynamic Certification In Ukraine", *Proceedings of the 5th International Conference of Young Scientists "Geodesy, Architecture & Construction"*, pp.112-113, 2013.

[3] V. Dorofeev, K. Yegupov, A. Murashko, O. Adamov, "A new approach to buildings seismic resistance assessment in Ukraine", *Proceedings of the 2nd European Conference on Earthquake Engineering and Seismology*, 2014, pp. 138–143.

[4] Weep holes in NiCore hollow-core plank. [Online]. Available: https://nitterhouseconcrete.com/weep-holes-in-nicore-plank/.

[5] Broken Hollowcore Plank. [Online]. Available: https://www.eng-tips.com/viewthread.cfm?qid=481848.

[6] Non-destructive testing of concrete. [Online]. Available: https://www.sciencedirect.com/science/article/abs/pii/0007362874900139?via%3Dihub

[7] Non-Destructive Testing of Concrete: A Review of Methods. [Online]. Available: https://www.researchgate.net/publication/282938427_Non-Destructive_Testing_of_Concrete_A_Review_of_Methods

[8] NON-DESTRUCTIVE TESTING OF CONCRETE STRUCTURES. [Online]. Available: https://www.researchgate.net/publication/326977558_NON DESTRUCTIVE_TESTING_OF_CONCRETE_STRUCTURES

[9] Use of Non-Destructive Tests for Reinforced Concrete Damage Assessment. [Online]. Available: https://iopscience.iop.org/article/10.1088/1757-899X/640/1/012037

[10] Non-destructive methods of concrete quality control as factor in reliability of concrete and reinforced concrete structures in transport facilities. [Online]. Available: https://www.researchgate.net/publication/324750111_Non-destructive_methods_of_concrete_quality_control_as_factor_in_reliability_of_concrete_and_reinforced_concrete_structures_in_transport_facilities

СПРОЩЕНИЙ НЕРУЙНІВНИЙ МЕТОД ВИЗНАЧЕННЯ ЦІЛІСНОСТІ ПУСТОТНИХ ПЛИТ ПЕРЕКРИТТІВ

[1]**Мурашко О.В.,** д.т.н., доцент,
alexeymurashko@gmail.com, ORCID: 0000-0002-2812-5951
[2]**Калініченко А.С.,**
kb2a.precast@gmail.com, ORCID: 0000-0001-9237-4218
[2]**Стебельський А.Л.,**
stebelsky.budova@ukr, ORCID: 0000-0002-0321-478X
[3]**Кубійович М.І.,**
kubiyovych_m@ukr.net, ORCID: 0000-0002-8500-032X
[1]**Волощук В.В.,** аспірант,
vadims9292@gmail.com, ORCID: 0000-0001-6259-7090
[1]*Одеська державна академія будівництва та архітектури*
вул. Дідріхсона,4, м. Одеса, 65029, Україна,
[2]*Колективне підприємство «Будова»*
вул. Осипова, 25, м. Одеса,65012, Україна,
[3]*Приватне підприємство «Капітель-М»*
вул. Армійська, 8-б, оф-8, м. Одеса, 65058, Україна

Анотація. У статті наведено результати аналізу плит перекриттів залізобетонних багатопустотних попередньо напружених стендового безопалубного формування, що виготовляються за екструзивною технологією щодо наявності дефектів, що утворилися в результаті поєднання ряду кліматичних явищ під час будівництва об'єкта. Поява такого роду дефектів часто зустрічається в будівельній практиці. Питання усунення причин таких дефектів, а також посилення пошкоджених перекриттів не є предметом дослідження.

Метою проведеного аналізу було виявлення пошкоджень бетону та порушень цілісності ребер плит, які не завжди доступні, при візуальному обстеженні. Існуючі методи неруйнівного контролю за допомогою спеціалізованого обладнання дають можливість визначити міцність бетону, а також наявність тріщин та їх конфігурацію у виробах. До недоліків таких методів слід віднести: високу вартість обладнання, необхідний рівень кваліфікації фахівців, що його використовують, і неможливість його застосування для масової перевірки цілісності плит.

Тому виникла потреба у розробці методу виявлення дефектів у збірних конструкціях для оперативної перевірки за умов будівельного майданчика. Пропонований метод дозволяє швидко перевіряти наявність значних дефектів у виробі завдяки аналізу на слух звуку від ударів слюсарним молотком по перекриттю. Спрощений метод визначення цілісності пустотних плит дозволяє звузити обсяг ретельних і трудомістких інструментальних досліджень при повному обстеженні об'єкта, виділивши місця, що потребують ретельного обстеження пошкоджених ділянок конструкцій із загального обсягу збірних перекриттів об'єкта.

За результатами дослідження визначено, що звук можна розділити на три основні типи, що характеризують характер дефекту конструкції: дзвінкий звук свідчить, що конструкція не пошкоджена, глухий звук – конструкція пошкоджена тріщинами ближнього залягання, проміжний звук – у конструкції є тріщини глибокого залягання, переважно у вертикальному ребрі.

Ключові слова: плити перекриттів залізобетонні багатопустотні попередньо напружені стендового безопалубного формування, тріщина, бетон, метод контролю, звук, дефект.

УПРОЩЕННЫЙ НЕРАЗРУШАЮЩИЙ МЕТОД ОПРЕДЕЛЕНИЯ ЦЕЛОСТНОСТИ ПУСТОТНЫХ ПЛИТ ПЕРЕКРЫТИЙ

[1]**Мурашко А.В.,** д.т.н., доцент,
alexeymurashko@gmail.com, ORCID: 0000-0002-2812-5951
[2]**Калиниченко А.С.**,
kb2a.precast@gmail.com, ORCID: 0000-0001-9237-4218
[2]**Стебельський А.Л.**,
stebelsky.budova@ukr, ORCID: 0000-0002-0321-478X
[3]**Кубийович Н.И.**,
kubiyovych_m@ukr.net, ORCID: 0000-0002-8500-032X
[1]**Волощук В.В.,** аспирант,
vadims9292@gmail.com, ORCID: 0000-0001-6259-7090
[1]*Одесская государственная академия строительства и архитектуры*
ул. Дидрихсона,4, м. Одесса, 65029, Украина,
[2]*Коллективное предприятие «Будова»*
ул Осипова,25, м. Одесса,65012, Украина,
[3]*Частное предприятие «Капитель-М»*
вул. Армейская,8-б,оф-8, м. Одесса, 65058, Украина

Аннотация. В статье приведены результаты анализа плит перекрытий железобетонных многопустотных предварительно напряженных стендового безопалубочного формования, изготавливаемых по экструзивной технологии на предмет наличия дефектов образовавшихся в результате сочетания ряда климатических явлений во время строительства объекта. Появление такого рода дефектов довольно часто встречается в строительной практике. Вопросы устранения причин таких дефектов, а также усиления поврежденных перекрытий не являются предметом данного исследования.

Целью проведенного анализа было выявление повреждений бетона и нарушений целостности ребер плит, которые не всегда доступны при визуальном обследовании. Существующие методы неразрушающего контроля с помощью специализированного оборудования дают возможность определить прочность бетона а также наличие трещин и их конфигурацию в изделиях. К недостаткам таких методов следует отнести: высокую стоимость оборудования, необходимый уровень квалификации использующих его специалистов и невозможность его применения для массовой проверки целостности плит.

Поэтому возникла необходимость в разработке метода выявления дефектов в сборных конструкциях для оперативной проверки в условиях строительной площадки. Предлагаемый метод, позволяет быстро проверять наличие значительных дефектов в изделии благодаря анализу на слух звука от ударов слесарным молотком по перекрытию. Упрощенный метод определения целостности пустотных плит позволяет сузить объем тщательных и трудоемких инструментальных исследований при полном обследовании объекта, выделив места нуждающиеся в тщательном обследовании поврежденных участков конструкций из общего объема сборных перекрытий объекта.

По результатам исследования определено, что звук можно разделить на три основных типа, характеризующих характер дефекта конструкции: звонкий звук свидетельствует, что конструкция не повреждена, глухой звук – конструкция повреждена трещинами ближнего залегания, промежуточный звук – в конструкции имеются трещины глубокого залегания, преимущественно в вертикальном ребре.

Ключевые слова: плиты перекрытий железобетонные многопустотные предварительно напряженные стендового безопалубного формования, трещина, бетон, метод контроля, звук, дефект.

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