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FIELD TESTS OF IMPACT NOISE INSULATION OF THE FLOOR USING PLANNING THEORY

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Abstract. In modern construction, one of the main indicators of the quality of housing for users of multi-storey buildings is still noise. The task of preventing the noise that occurs in the house itself needs to be given more attention when designing and soundproofing. It is known that extraneous sounds penetrating into a living space cause a negative impact not only on the psychological state of a person, but also on the physical one. In this regard, each user of the premises wants to receive comfortable conditions for staying in them. To achieve this condition, it is necessary to develop effective structural and technological schemes for soundproofing the floor from impact noise, as well as their verification and evaluation using the theory of planning experiments.

This article is devoted to solving an important issue of sound insulation of floors in monolithic reinforced concrete multi-storey residential buildings, namely from impact noise. The article considers the structural and technological schemes of sound insulation of the floor of fifteen types, using different materials and their combinations to achieve regulatory requirements for sound insulation from impact noise.

It was determined that the thickness of the layer of materials and the density have a significant effect on the insulation performance against shock noise. The work investigated floor constructions based on layers of changing materials. Specifically, such parameters as the thickness (50±10 mm) and density (300±50 kg/m^3) of polystyrene concrete "Izolkap" and the thickness of the semi-dry screed (50±10 mm).

When choosing the most rational design and technological scheme used the results of planning theory, as well as indicators of reduced impact noise, obtained as a result of field tests, it allowed to choose the most rational and effective version of "floating" floor – based on materials "Akuflex" and "Izolkap" (polystyrene concrete) – scheme №11, the index of the reduced level of impact noise is Lnw = 52 dB.

The arrangement of the structural and technological scheme of floor sound insulation №11 allows to reduce the level of initial impact noise in the room by 37.5%.

Keywords: sound insulation, impact noise, "floating" floor, multilayer system.

Introduction. In modern construction, one of the main indicators of the quality of housing for users of multi-storey buildings is still noise. Noises can be heard both from the street – technogenic and biogenic (noise from transport, stadium, open entertainment clubs), and from housemates. Massive or multi-layer building envelopes and efficient window systems help to prevent outside noise. In turn, the tasks of preventing noise that occurs in the house itself must be given more attention when designing and soundproofing. Since it is known that extraneous sounds penetrating into a living space cause a negative impact not only on the psychological state of a person, but also on the physical one, therefore, in this regard, each user of the premises wants to receive comfortable conditions for staying in them. To create such conditions, it is necessary to develop effective design and technological schemes for soundproofing the floor, as well as their verification and evaluation.

Recent research researches and publications results. There are two main types of noise in the construction industry: airborne and structural. It should be noted that noise is understood as a chaotic mixing of sounds. Airborne noise is transmitted through air, while structural noise is transmitted through a solid body. One of the types of structural noise is shock [1]. So, in most of the series of houses that were built in the last century, central heating was arranged. In such systems, metal pipes were used to supply the coolant to the heating radiators. At the same time, strikes on the central heating radiator, for example, during repairs on the ground floor of the house, are most likely to be heard by residents, even at a considerable distance from the source.

An analysis of sources showed that during the construction of frame-monolithic buildings, for the most part, sound insulation by the developer is not provided for housing, especially economy or comfort class [2-4]. But, at the same time, it largely depends on the materials that were chosen for the construction of buildings. Thus, internal inter-apartment walls, which in the vast majority of buildings are made of aerated concrete, have a lower rate of sound insulation from airborne noise than walls made of ceramic bricks. At the same time, walls with ceramic walls have similar indicators in terms of airborne noise insulation, which, due to the structural features of buildings, are made of monolithic reinforced concrete. However, this significantly increases the impact noise penetration rate.

In turn, for developers who position themselves as builders of luxury real estate, the use of high-quality and effective sound insulation in buildings is required. At the same time, the issue of additional soundproofing of premises from the developer comes to the fore. In this case, the fact that at the stage of building construction, the complex sound insulation of floors, walls, communications, reduces the level of penetration of various types of noise is not ruled out.

In many new residential complexes and old buildings, residents have to independently carry out construction work that is aimed at getting rid of noise [5-7]. At the same time, they, first of all, need to decide which type of noise they need to deal with. Because for different types of noise and insulated structures there are their own design and technological solutions. In most cases, only complex insulation of ceilings and walls will help to solve issues related to sound insulation and achieve comfortable conditions in the premises.

It is known that the level of insulation of airborne noise of an interfloor ceiling or load-bearing walls is determined, first of all, by the massiveness and thickness of the structure. However, this solution is not always economically feasible. In the case of insulation from impact noise, in most cases it is necessary to apply special technological solutions using additional structures. Thus, for isolation from the types of noise discussed above, it is necessary to apply unique design and technological solutions.

One of the structures through which structural noise is transmitted are floor slabs, monolithic or prefabricated. This is especially true for frame-monolithic or prefabricated buildings, which have been built in large numbers since the beginning of the 21st century. One of the most effective ways to deal with this type of noise is, from the point of view of building acoustics, the construction of a "floating" floor [7, 8].

This design is a massive screed of fine-grained concrete (often with a semi-dry cement-sand mixture) or lightweight concrete, which are laid on the interfloor overlap over a layer of material with elastic properties. At the same time, the "floating" floor screed should not have rigid connections with both the load-bearing and enclosing structures of the building [9]. To do this, it is separated from the side surfaces of walls, diaphragms and partitions with elastic gaskets (damper tape). As the material of the insulating layer, in most cases, slabs of acoustic mineral wool on a basalt or fiberglass base are used. It is also possible to use various types of foamed polymeric or fibrous roll materials.

The sound insulation index of a floating floor depends on the thickness and structure of the screed material and the elastic properties of the gasket material. In some cases, the use of various types of soundproofing materials can achieve a reduction in impact noise by more than 40 dB. Therefore, the search for optimal design and technological solutions and materials that are aimed at obtaining structures that provide standard sound insulation indicators becomes an urgent task.

Materials and methods of study. In the structures under study, the thickness of the monolithic reinforced concrete floor slab was 180 mm. In turn, for isolation from impact and structure-borne noise, a simple thickening of the structure is not effective. Therefore, it is necessary to use specially developed and more effective design and technological solutions for floor soundproofing.

The studies were carried out in natural conditions, in apartments of houses built according to a frame-monolithic scheme. Two apartments are allocated for each type of floor soundproofing construction. This is necessary for the reliability of the results obtained and the elimination of the error factor in the performance of works [10]. The following materials were used in the research:

– "Izolkap" – polystyrene concrete, which is a light mixture for the installation of heat and sound insulating screed, which consists of Portland cement and filler treated with a special additive. As a filler, inert expanded polystyrene granules (Ø 6-8 mm) are used, with high thermal insulation ability. The material belongs to the class of lightweight concrete.

– "Akuflex" is a rolled material based on specially processed polyester fibers, developed in accordance with modern requirements for room acoustics and working to absorb impact noise. The material is used as a soundproofing base in the construction of "floating" floors. It is a layer between the screed and the floor finish. In addition, "Akuflex" can be used as a damping layer under the screed for additional insulation against impact noise.

Experimental planning theory was used to conduct experimental studies. In accordance with this theory, a 15-point plan of experimental studies was used. In it, each of the factors changes at three different levels [11]. They are conditionally designated -1, 0 and +1.

The following factors and levels of their variation were adopted in the work, Table 1:

– thickness of the layer "Izolkap" (X_1) – (50 ± 10) mm;

– thickness of the c/p screed (X_2) – (50 ± 10) mm;

– density of "Izolkap" (X_3) – (300 ± 50) kg/m^3.

Table 1 – Factors and levels of their variation

Levels of variation	Factors		
	X_1	X_2	X_3
	Thickness of the layer "Izolkap", mm	Thickness of the layer c/s screed, mm	Density of "Izolkap", kg/m^3
-1	40	40	250
0	50	50	300
+1	60	60	350

Factors of the thickness of the material "Izolkap" (polystyrene concrete) and the thickness of the c/p screed can affect the impact and airborne sound insulation, and also affect the complexity and time of work.

The density factor of the "Izolkap" material directly affects the impact noise index, since the greater the density, the more cement in the material, which increases the impact noise index, and this also affects the complexity of laying the material and the time of work.

The studies were carried out using a 15-point three-factor experiment plan, which is shown in Table 2.

Table 2 – Experiment plan

№ Scheme	x_1	x_2	x_3	"Izolkap", mm	C/s screed, mm	Density «Izolkap», kg/m^3
1	+1	-1	-1	60	40	250
2	+1	-1	+1	60	40	350
3	+1	0	0	60	50	300
4	+1	+1	-1	60	60	250
5	+1	+1	+1	60	60	350
6	-1	-1	0	40	40	300
7	-1	0	-1	40	50	250
8	-1	0	0	40	50	300
9	-1	0	+1	40	50	350
10	-1	+1	0	40	60	300
11	0	0	0	50	50	300
12	0	-1	+1	50	40	350
13	0	-1	-1	50	40	250
14	0	+1	-1	50	60	250
15	0	+1	+1	50	60	350

Research results. Work performance technology. Organizational and technological processes of the device of constructive and technological schemes of the floor.

1. Preparatory work. Leveling the floor slab (filling depressions and caverns, beating off large influxes of concrete), as well as grouting the fixings of the facade slab to the floor slab with mortar and grouting geodesic holes in the floor slab.

Installation of a damper tape around the perimeter of the premises Fig. 1, and cleaning the surface from debris, as well as dedusting the surface.

Fig. 1. Installation the damper tape

2. The installation of the material "Izolkap". Preparatory work (kneading and supply of material, lifting tools, equipment to the floor). The material device process is shown in Fig. 2.

Fig. 2. The installation of "Izolkap"

3. The device of the material "Akuflex".

3.1. Preparatory work for the device material "Akuflex":

A) Partial sealing of the surface of the coating in places of formation of cavities and junctions of heating pipes with "Izolkap" material, cleaning of sags on a previously made surface.

B) Cleaning the damper tape from contamination with "Izolkap" material.

3.2. Laying material "Akuflex". It is produced by gluing rolls of material to each other with reinforced tape, with an overlap of 5-10 cm, as well as gluing the roll to a damper tape. The process of laying the "Akuflex" material is shown in Fig. 3.

Fig. 3. Laying material "Akuflex"

4. Installation of a cement-sand screed Fig. 4.

Fig. 4. Installation of a cement-sand screed

Measurements of sound insulation of reduced impact noise consist of the following stages: preparation for testing premises; measurement of the level of impact noise under the ceiling when creating shock effects on it; processing of measurement results.

Research equipment. For acoustic studies, the following set of measuring equipment was used:

- Acoustic multifunctional counter "Octava-ECOPHYSICS";
- Standard percussion machine "UM-10";
- Microphone dBx;
- Software package for measurement of reverberation time based on PC;
- Preamp P200;
- Acoustic system dB Technologies OPERA 605D.

Measurement of impact noise insulation was carried out according to the methods of DSTU B V.2.6-86:2009 (Fig. 5), calculation according to DSTU B V.2.6-85:2009.

The results of field tests are shown in Table. 3. Floor structures No. 1, 2, 4, 7, 11, 14 – comply with regulatory requirements, floor structures No. 2, 3, 5, 6, 8, 9, 10, 12, 13, 15 – do not comply with regulatory requirements.

Table 3 – The results of field tests

№№ p/p	Plan line number														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
L'nw, dB	54	57	56	52	56	55	53	56	56	57	52	57	56	52	57

Fig. 5. Measurement of impact noise insulation

Prospects for further research. It should be noted that it is necessary to study the cost of arranging such floors. This will make it possible to optimize these works not only in terms of structural features, but also in terms of the economic component.

Conclusions:

1. The results of full-scale studies of structures for impact noise using the theory of planning experiments made it possible to choose the most rational option for sound insulation.
2. It has been established that the arrangement of the structural-technological scheme for soundproofing floor no. 11 makes it possible to reduce the level of the initial (uncoated reinforced concrete slab) impact noise in the room by 37.5%.
3. Floor structures with thicknesses of "Izolkap" materials (with a density of 250 and 300 kg/m^3) and a c/s screed of 40 mm are not sufficient and will not satisfy the strength indicators, which in the future may lead to rapid wear and destruction of the structure.
4. Floor structures with thicknesses of "Izolkap" materials (with a density of 300 and 350 kg/m^3) and a 50 mm c/s screed are sufficient and meet the necessary sound insulation and strength requirements.

5. Floor structures with thicknesses of "Izolkap" materials (with a density of 300 and 350 kg/m^3) and a cement/sand screed of 60 mm are sufficient and meet the necessary requirements for sound insulation and strength, but are more difficult to manufacture and are not economically viable.

6. The work requires further research, thanks to which the optimal insulation parameters will be determined, taking into account the cost of installing such floors.

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НАТУРНІ ДОСЛІДИ ІЗОЛЯЦІЇ УДАРНОГО ШУМУ З ВИКОРИСТАННЯМ ТЕОРІЇ ПЛАНУВАННЯ

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Анотація. У сучасному будівництві одним з основних показників якості житла для користувачів приміщень багатоповерхових будинків залишається шум. Завданням перешкоджання шуму, що виникає в самому будинку, необхідно приділити більшу увагу при проектуванні та влаштуванні звукоізоляції. Відомо, що сторонні звуки, що проникають у житлове приміщення, стають причиною негативного впливу не лише на психологічний стан людини, а й на фізичний. У зв'язку з цим кожен користувач приміщень хоче отримати комфортні умови перебування в них. Для досягнення цієї умови необхідно розробити ефективні конструктивні та технологічні схеми звукоізоляції підлоги від ударного шуму, а також їх перевірки та оцінки з використанням теорії планування експериментів.

Дана стаття присвячена вирішенню важливого питання звукоізоляції перекриттів монолітних залізобетонних багатоповерхових житлових будинків, а саме від ударного шуму. У статті розглянуто конструктивно-технологічні схеми звукоізоляції підлоги п’ятнадцяти типів із застосуванням різних матеріалів та їх комбінацій для досягнення нормативних вимог до звукоізоляції від ударного шуму.

Визначено, що на показники ізоляції від ударного шуму досить вагомо впливає товщина шару матеріалів та щільність. В роботі досліджувалися конструкції підлоги на основі шарів матеріалів, що змінювалися. А саме такі показники як товщина (50±10 мм) та щільність (300±50 кг/м^3) полістиролбетону «Izolkap» та товщина напівсухої стяжки (50±10 мм).

При виборі найбільш раціональної конструктивно-технологічної схеми використовувалися результати теорії планування, а також показники зниженого ударного шуму, отримані в результаті натурних випробувань, що дозволило вибрати найбільш раціональний і ефективний варіант «плаваючої» підлоги – на основі матеріалів «Акуфлекс» та «Ізолкап» (полістиролбетон) – схема №11, показник приведеного рівня ударного шуму Lnw = 52 дБ, що на 9,1% менше за нормативний.

Влаштування конструктивно-технологічної схеми звукоізоляції підлоги №11 дозволяє знизити рівень початкового (залізобетонна плита без покриття) ударного шуму в приміщенні на 37,5%.

Ключові слова: звукоізоляція, ударний шум, «плаваюча» підлога, багатошарова система.

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