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ENHANCEMENT OF SOUND INSULATION OF FLOORS USING LIGHTWEIGHT CONCRETE BASED ON NANOSTRUCTURED GRANULAR AGGREGATE

Ruslan Valerievich Lesovik, Larisa Nikolaevna Botsman, Victoria Nikolaevna Tarasenko and Alexey Nikolaevich Botsman
Belgorod State Technological University named after V.G. Shoukhov, Russian Federation, Belgorod, Kostyukova

ABSTRACT

Recently, on the territory of the Russian Federation, and in particular in the Belgorod region individual and private construction is well developed. Not enough attention is paid to problems of impact sound isolation for floor construction in free-standing residential buildings. Actually, solution of these problems concludes in balance between physical and mechanical properties, efficiency, environmental friendliness as well as resistance of heat transmission in builds. Application of concrete based on granular nanostructured aggregate as damping material for the constructing of a floating floor is proposed.

Keywords: sound insulation, sound adsorption, impact sound, «floating» floor, walling, granulated nanostructuring aggregate.

INTRODUCTION

Realization of the regional grant programme «Development of housing construction in the Belgorod region in 2011-2015» provides for the market formation of economic housing that meets the requirements of energy efficiency and sustainability, as well as complex solution the problem of transition to sustainable functioning and development of the housing sector to ensure the housing availability for citizens, as well safe and comfortable living in it.

In 2012, according to data of the regional department of construction, transportation, housing and utilities infrastructure, more than 1 million square meters of individual housing construction sector is entered into exploitation. Almost 11,000 Belgorod families celebrated a housewarming. Eight thousand of these families – in private homes, and about three thousand ones - in high-rise residential apartment buildings.

The total volume of housing, built in the region (individual housing construction and apartment building) does not fall below one million square meters for five years (in 2012 it was issued 1.2 million square meters of housing). But «the millionth» milestone of individual homes was managed to overcome the first time. According to data of Nikolai Kalashnikov the Head of the Department of Construction, Transport and Housing Belgorod region individual housing construction (IHC) in the overall structure of objects introduced in 2012 was 84% [1].

By the early 2013 about 15 000 of individual houses and 95 of apartment buildings in the Belgorod region were building. Local government are also actively support IHC and expect that by 2015 the total volume of new housing will be 1.5 million of square meters, where 1.2 million of which ones will be individual housing. The regional program «Promotion of housing construction in the Belgorod region in 2011-2015» is oriented for this.

Realization of the regional purposed program «Development of housing construction in the Belgorod region in 2011-2015» provides for the formation of affordable housing development that meets the requirements of energy efficiency and sustainability, as well as focused on integrated solution for transition to sustainable functioning and development of the housing sector to ensure the availability of housing for citizens, safe and comfortable living in it. [2].

In the city of Belgorod and Belgorod region the large part of the market of wall construction materials based on cellular concrete is presented by small wall stones based on gas concrete as well as foam- and claydite-foam concrete small blocks. Together with it the structural heat-insulating cellular concrete based on nanostructured aggregate are actively implemented [3, 4].
Noise protection in individual housing construction is important. It should be noted the influence of finishing materials of interior space and effect of sound absorption and sound reflection in general.

As basic areas aimed to solve the problems of sound insulation in individual residential building should be highlighted followings:

- space-planning decision, allowing enduring and further isolating the especially noise zones in housing areas (blocking the kitchen, bathroom and furnace room into a single unit and use them for decoration of compact wall materials with following facture applying;
- feature of constructive solutions (using of baffles increased porosity and with thickness of 190 mm or high density and monolithic, materials is supposed. In these cases the erection of additional with a space is used)
- informed choice of finishing materials for walls, floor and ceiling (protection against air and structural noise should be maximized).

Special attention should be paid to the floor structure. From point of view of energy efficiency the system of «floating» floors is the most favorable. The

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system allows leveling harmful effects of structural noise or minimizing them with rational choice of floor construction.

Main part

From the perspective of building acoustic the design of «floating» floor is the most important and most effective way to increase the impact sound insulation.

The level of airborne sound insulation with interflooring is determined primarily by floor slabs massiveness and thickness. However in respect of impact sound insulation problem is always solved by additional structures using.

Reduction of impact noise is achieved in two main ways:

- use of enough elastic materials as finish flooring (linoleum, carpet, etc.);
- design of additional «floating floor» construction over the floor slab

In the first case, an increase in sound insulation is determined by the energy losses on the deformation of the material of finished floor - linoleum or carpet. Effectiveness of this method is limited and is 12-16 dB.

In the second case, the sound insulation increase is determined by effectiveness of the resonance system «mass-spring-mass» (see Figure-1), where the masses are slab and tie, and spring - the elasticity of the sound insulation seleant. Soundproofing ability of «floating»floor depends on screed massiveness and elastic properties of packing block, and typically is 23-28 dB.

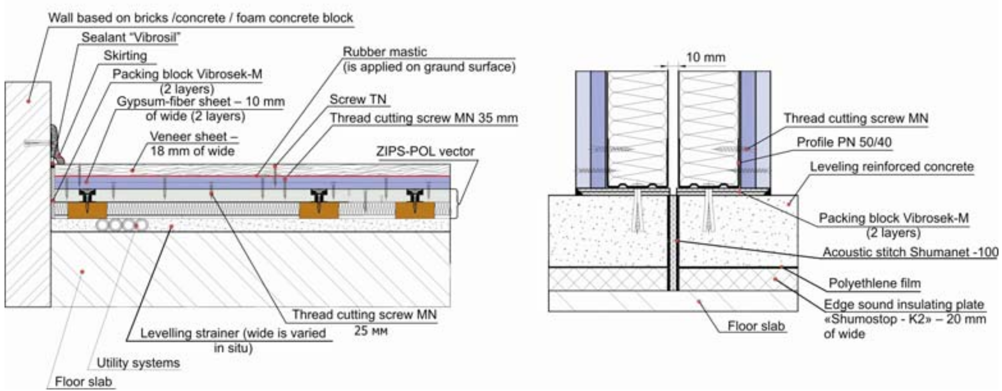

Figure-1. System «mass - spring - mass» on the design of a floating floor (a) and construction of the partition (b) on a double frame independent, adjacent to the «floating» floor.

This is especially prospective if you consider that floor slabs of all types in residential buildings are [5] differed from the normalized values at 18-25 dB according to calculations (Tables 1, 2).

Table-1. Normative values of the insulation index of air and structural noise for residential buildings according to CH 23-103-2003.

№ п/п	Name and position of enclosure structure	R_w, dB	L_{nw}, dB
1	Floor slabs between rooms of apartment as well as between apartments rooms and holes, stairwells, attic floor		
	In buildings of A category	54	55
	In buildings of B category	52	58
	In buildings of C category	50	60
2	Overlap between the rooms in the apartment on two levels:		
	In buildings of A category	47	63
	In buildings of B category	45	66
	In buildings of C category	43	68
Note: category A - high comfortable conditions; category B - comfortable conditions; category C - maximum permissible conditions.			

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Table-2. Calculated indexes of structural noise insulation for slab based on reinforced concrete.

Surface density of floor slab, kg/m^2	**150**	**200**	**250**	**300**	**350**	**400**	**450**	**500**	**550**	**600**
Calculated value L_{nw}, dB	46	44	42	40	38	37	36	35	34	33

Development of production of lightweight concrete with porous aggregates that were originally intended for primarily using in cladding, led to the use of these ones in the interior construction of residential buildings. Under certain raw materials and industrial bases of prefabricated housing complex application for the production of lightweight concrete structures residential building is economically feasible. However, the use of concrete in the inside fences is limited by requirements for sound insulation [6].

According to the calculation methods of [6] to obtain the desired sound-insulation the acoustically homogeneous light concrete structure should have the same surface density as that of heavy concrete based fence. This is associated with a significant increase in the thickness of light concrete elements, compared with the thickness of the heavy-weight concrete structures and significant reducing in their effectiveness. However, there are data showing increased sound insulation qualities of light concrete fence [7].

In individual housing construction the ground floor provides performance monolithic pouring by keramzite concrete layer with thickness of 120-150 mm, the use of heaters (usually mineral or polystyrene) with a minimum thickness of 100 mm. But often, the choice of material preparation is a compromise between economic and thermal performance. Also an important role has complexity and speed of installation.

As the material of damping device floating-floor construction the slabs as packing blocks based on nanostructured granular aggregate (NGA) are proposed to use [8].

The main parameters that would make the choice of material are the strength, water vapor permeability, water requirement, and thermal resistance. Basic physical and mechanical characteristics of the proposed materials are given in Table 3.

Table-3. Properties of structural and heat-insulating concretes depending on the composition.

№	Concrete composition, WT / кg/m^3: binder: cement	binder: cement + tine graund cement stone	coorse aggregate: NGA	coorse aggregate: keramzite gravel	tine aggregate: sand	Physical-mechenical properlies: density, кg/m^3	heat conductivity, W/m·K	compressive strength, MPa	water absorbtion, %	porosity, %	freeze-thaw resistance, cigles	weaking coefficient
1	1/250	–	–	2,12/530	1,74/435	1200	0,36	11,5	15	45	35	0,72
2	1/310	–	–	1,61/500	1,4/435	1300	0,47	13,5	20	40	40	0,75
3	1/312	–	2,02/630	–	1,35/420	1200	0,15	10,5	3,8	55	35	0,8
4	1/298	–	2,11/630	–	1,45/432	1300	0,30	11,2	6	50	40	0,85
5		1/280	2,25/630	–	1,6/448	1200	0,15	10,6	3,6	55	35	0,82
6	–	1/267	2,36/630	–	1,37/459	1300	0,30	11,5	5,8	50	40	0,87

Such products can be produced as plates - inserts with a thickness of 50-100 mm, the wide corresponds to the step of rail - 500 or 600 mm, the length - 500 or 1000 mm.

CONCLUSIONS

A comparison of performance characteristics of developed concrete based on NGA [9] and keramzite-concrete was accomplished (Figure-2). Results of the tests showed an increase in the total porosity of the composite due to the introduction of NGA to 55-60 % its thermal conductivity is reduced by 2-2.5 times (Figure-2a) compared with the same density for keramsite-concrete. For the same cost it provides improving physical and mechanical properties of 2 times and to reduce the thickness of preparation layer by 25-50 %. This is due to the pore formation with compacted wall and polytextural surface that reduces heat flow in the total composite [10].

Increase of macroporosity of concrete, including NGA, is takes place due to the dissolution of the granules forming the core components. At the same time concrete matrix surrounding the pellet loses its porosity then faster then more actively of pellet nuclei substance is dissolved. This reaction more intensively reduces the porosity of the concrete matrix, so the density dependence of the total porosity of the concrete and in this case is a gentle character (Figure-2).

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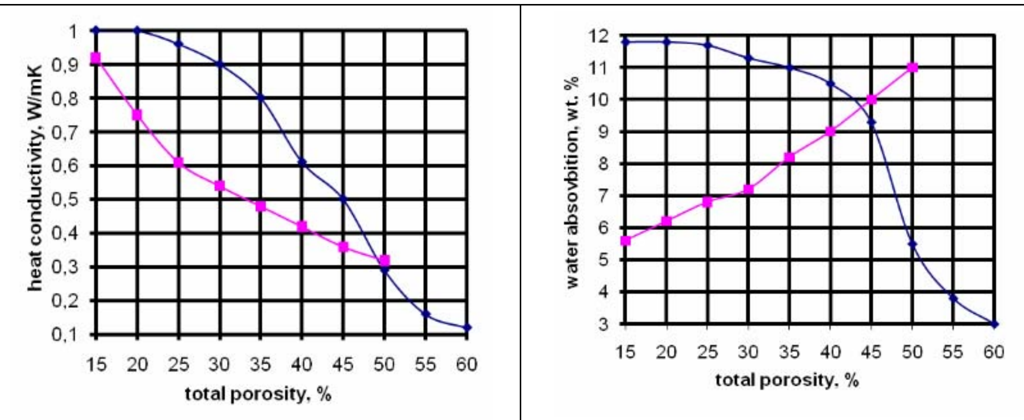

a b

Figure-2. The concrete performance characteristics in dependence of total: a - heat conductivity; b - water absorption capacity; - keramzite-concrete,- NGA based concrete.

Character reduce water absorption of concrete specimens with NGA is diametrically differenced from the traditional concrete lightweight aggregates (Figure-2b). In particular, water absorption of keramzite-concrete is increased to 23-27 wt. %.by increasing of total porosity to 55-60 %. With decreasing densities and increasing of total porosity of the developed concrete the water absorption is reduced by 4 times compared to the reference lightweight concrete. Due to the formed pores in place of granular aggregate based on silica-containing materials (Figure-3), have compacted walls and prevent to migration of water, thus increasing the water resistance and water resistance of concrete construction products in general. Also it should be noted that 95 % of the obtained composite macropores are closed and watertight.

Figure-3. The sample of constructive heat-insulating lightweight concrete with NGA after filing.

It can be associated with significant proportion of the closed porosity, formed by granules which due to chemical reactions with cement system fill it by insoluble compounds that bridging micropores in concrete and prevent the water absorption. The increasing the percentage of the granules and, as a consequence, the total porosity of the material, it is possible to achieve reduction in the open porosity of the concrete, favorably affects the physical, mechanical and performance properties of the material.

Thus, concrete products, containing granular composite filler and exposured in steam curing under atmospheric pressure, are also characterized by enhanced heat insulation properties. Wherein the change in material costs in comparison with the keramzite based composition shows a decrease in total expenses.

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Table-4. Change in the material costs in the cost of 1 m^3 of lightweight concrete.

Expenses	metric unit	Concrete based on:					
		keramzite			NGA		
		Cost, rub	Norm for consumption	Total cost, rub.	Cost, rub	Norm for consumption	Total cost, rub.
Components:							
Cement	kg	3,50	138,46	484,62	3,00	123,08	369,23
Keramzite	m^3	1350,00	0,65	877,50	0,00	0,00	0,00
NGA	kg	–	–	–	956,90	0,70	669,83
Sand of Ziborovsk mine	m^3	700,00	0,40	280,00	700,00	0,36	248,89
Water	m^3	20,00	0,09	1,80	25,00	0,11	2,75
Total		1643,92			1290,70		

Summary

The possibility of the use of the above materials as a damping device when construction the insert of all types of floors, including floating» floors is established. The use of such materials when floor coating allows to eliminates the keramsite, reduce material costs during installation without losing in quality of final structure.

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