АВТОКЛАВНИЯТ ГАЗОБЕТОН И ПРИЛОЖЕНИЕТО МУ КАТО ЗВУКОИЗОЛАЦИОНЕН МАТЕРИАЛ

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AUTOCLAVED AERATED CONCRETE AND ITS APPLICATION AS SOUND INSULATION MATERIAL

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Abstract:
Autoclaved aerated concrete (AAC) is a relatively new generation building lightweight material. Over the years, AAC has proven its properties and has taken its place among the good thermal insulation material. The specific structure of AAC and the possibility to impact on the technology of manufacturing are prerequisites in this group of materials other specific properties as acoustic and sound insulation properties to be developed.
The present paper discusses the specific requirements to sound insulation materials and how they could be achieved for autoclave worked aerated concretes.

Keywords:
Autoclaved Aerated Concrete (AAC), Acoustic Properties, Sound Insulator.

1. INTRODUCTION

Autoclaved aerated concrete (AAC) is one of the newest materials in civil engineering. Its industrial production has been started in the beginning of 20^{th} century [1]. AAC production is based on the principle of expanding the solid material by increasing its volume. For this purpose, it is necessary to reduce the particles size of the raw materials and to establish such conditions at which the fine granules will be interact and increase the interstitial spaces. Thanks to the specific and unique properties, AAC became very rapid development and wide application. Its main advantages are cheap and easy use on construction site with very good fire resistance and thermal insulation properties.

The prerequisites for the specific behavior of AAC are its inorganic nature and internal structure. Gas concrete consists more than 70% cavity [2, 3]. This value reflexes on the density

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of the material. Porosity and pore size distribution of aerated concrete varies considerably with the composition and method of curing.

The gas phase in AAC makes it not only a good thermal insulator but this is a precondition for good acoustic properties as well.

Sound is a wave described with a frequency and energy. The sound is propagated in the medium that consists of matter. Solid media have the highest values in sound transmission, while gas media gives the lowest values for propagation of the material. Sound is spread at 340 m/sec in the air, 3000 m/sec in the water, 4000 m/sec in the wood and 8000 m/sec in the steel.

Two are the main characteristics that describe the acoustic properties of materials:

- *sound absorption coefficient* α - quantity characteristic for the ability of material to absorb acoustic energy. If α>0,4 the material is very good sound absorber [4]. Such materials are generally porous and lightweight, have porosity greater than 75% with much more open pores (Fig. 1) with maximal diameter less than 2 mm [4, 5, 6, 7].
- *sound transmission loss TL* or *transmission coefficient* τ - quantity characteristics for the ability of material to reflect or block sound energy. Good barrier materials reflect sound, and are dense and nonporous [5]. As a requirement is the dynamic modulus of elasticity to be less than 1-2 MPa [4].

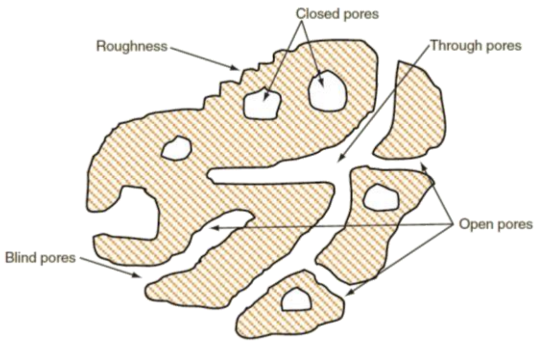


Figure 1. Types of porosities in materials [7]

Even its very high porosity AAC has a low sound absorption coefficient – 0.15-0.36 due to its very low density. [8]

To be the material a good air borne sound insulator it is required the minimum value of transmission loss to be TL>35dB [9]. Based on the Mass law and satisfying the written above requirement, Tada [9] obtained the following relation:

$$d.\ T > 50, \qquad (1)$$

where d – bulk density, kg/m^3; T – thickness, m.

However, many authors [8, 9, 10, 11] proved that sound insulation properties depends not merely upon the Mass law but also upon the rigidity and internal resistance of the material. The obtained by Tada [9] correlation between density and thickness of AAC, which satisfy the requirements for a good acoustic insulator, is presented on Fig. 2.

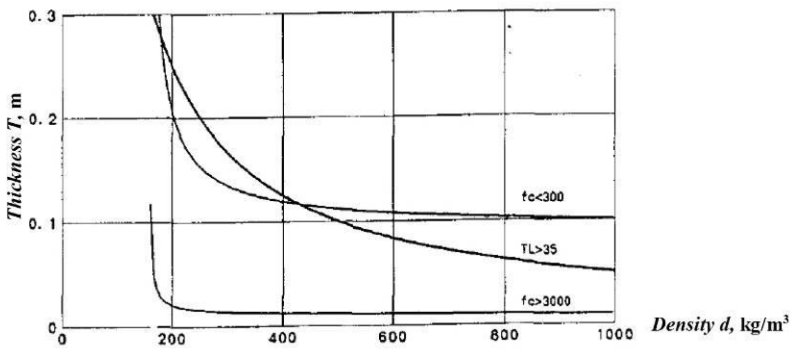


Figure 2. Combinations of density *d* and thickness *T* for acoustical requirements [9]

In [9] is concluded that AAC must have bulk density less than 400 kg/m^3 and thickness greater than 17 cm to face the main requirements for good sound and thermal insulator.

In [8] is argued that the value of sound absorption coefficient α depends on the thickness only when thickness is changed till 30-35 mm. The much greater influence has air permeability, which actually depends on the ration of connected pores to the total porosity (Fig. 3).

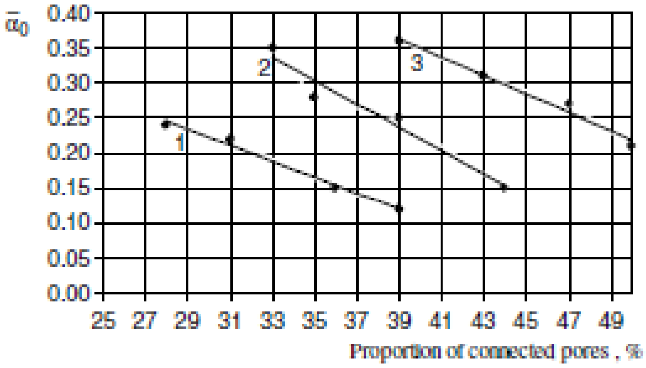


Figure 3. The dependence of the mean normal incidence absorption coefficient on the ratio of connected pores to total porosity for foam cement concrete (1); for gas cement concrete (2); for gas cement concrete with combined binder (3) [8]

The main aim of this paper is to study the behavior of blocks from autoclaved aerated concrete with different densities exposed at high level of sound. It is to evaluate the sound insulating properties of AAC, which is provoked of the established in practice fact that if there is no coating on low-density products, significant improvement in damping and echo values are occurred [12].

2. EXPERIMENTAL PROCEDURE

2.1. Materials

Two type of autoclave aerated concrete blocks with different density, porosity and moisture content were used for the experiments (Table 1). They were produced by the same casting technique.

Table 1. Testing materials

	Size, cm	Density, kg/m^3	Surface density, kg/m^2	Total porosity, %	Moisture, %
Block 1	50×25×10	140	14	85	10
Block 2	50×25×10	400	40	70	35

All the tests were carried out with the blocks with the same thickness – 10 cm.

It is not studied the influence of moisture on the sound insulation properties, because the samples are with very low level of moisture. Furthermore, according [13] even at high inside humidity (more than 55% till 100%) the difference in transmission losses is less than 10%.

2.2. Sound acoustic test

A special chamber was made for the acoustic tests (fig. 4) with inside dimensions 130×50×50 cm. The experimental equipment includes anti-vibration shock absorbers as well. Its dimensions are 120×10×15 cm.

a) b)

Figure 4. Outside view of the experimental equipment;
a) the chamber; b) anti-vibration shock absorbers

The sound level outside of the chamber was measured by Sound Meter Pro 2.5.7 - 4th set of Smart Tools® collection, with ± 2dB accuracy of 100 dB. It was positioned on distance of 20 cm from the chamber wall.

The sound inside the chamber was produced by a siren model TMX-SL290-13 with the sound output level 112 dB.

The measured siren sound inside the chamber was 87 dB. This value, which is indicated as I_0, was used as a base to calculate the absorption coefficient α, sound transmission losses TL and sound transmission coefficient τ [14].

3. RESULTS AND DISCUSSION

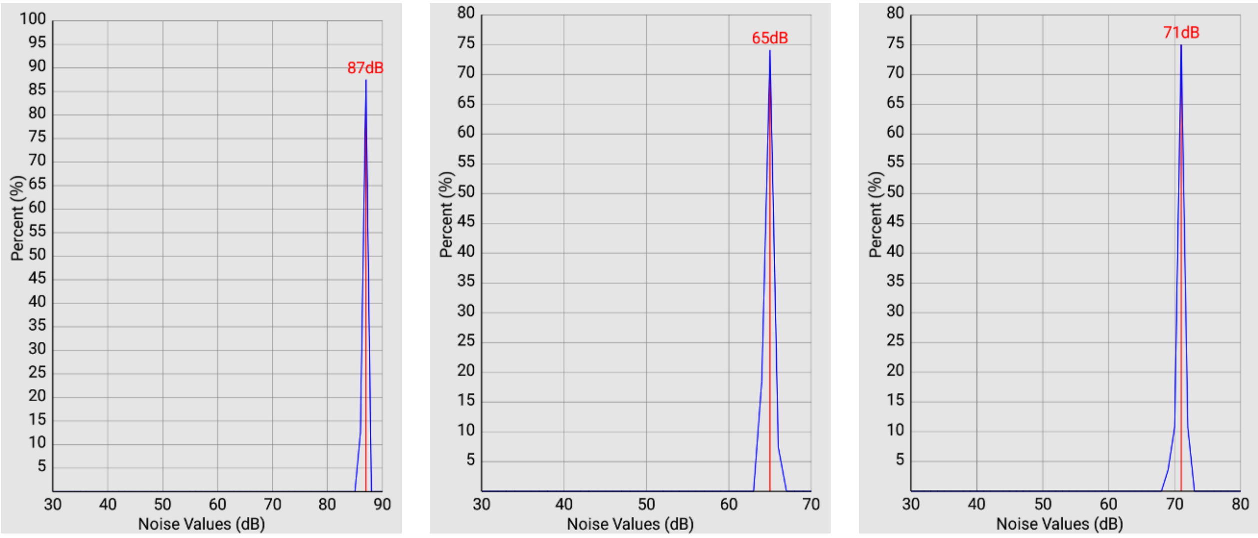
Sound insulation tests were carried out on AAC blocks with different densities to determine effect of density and porosity on acoustic properties of AAC. The results from the sound tests are presented in Table 2 and on Figure 5. The frequency of the sound wave is 2kHz.

Table 2. Testing results

	Sound level inside, I_0, dB	Sound level outside, I_t, dB	Sound reduction		Absorption coefficient α	Transmission coefficient τ	Transmission loss TL, dB
			ΔI, dB	%			
Siren	87	-	-	-	-	-	-
Block 1	87	65	22	25	0,26	0,74	22
Block 2	87	71	16	18	0,18	0,82	16

Block 1 provides higher sound reduction than *Block 2*. This could be explained with the lower density of the current AAC and its much more coarse and rough surface. It was estimated decreasing of 25% of the input sound level.

As a porous and lightweight material, it is expected the studied AAC blocks to have a good absorbing behavior. According the test results, *Block 1* has better absorption coefficient than *Block 2*, which is with 67% higher. However, it is not enough to classify *Block 1* as a very good sound absorber, because α_1<0,4. The results are comparable with those, shown in [8], as well.



a) b) c)

Figure 5. Measured sound level: a) inside the test chamber; b) outside the test chamber with walls from *Block 1*; c) outside the test chamber with walls from *Block 2*

Sound transmission coefficients of the both samples – *Block 1* and *Block 2*, are near to 1, respectively τ_1=0,74 and τ_2=0,82. The transmission losses are less than 35 dB, respectively TL_1=22dB and TL_2=18dB.

3. CONCLUSION

Analyzing the results it could be concluded that AAC *Block 1* has better sound insulating properties than AAC *Block 2*. The much more porous structure of *Block 1* realizes higher sound transmitting losses and respectively the material has lower transmission coefficient and higher sound absorption coefficient. Nevertheless, AAC *Block 1* could not be defined as a very good sound absorber. There is a need to conduct further in-depth research to evaluate precisely the acoustic properties of autoclaved aerated concrete with different characteristics – density, porosity, type of porosity, surface conditions, etc.

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