# Expanded obsidian as composite material for light concretes

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**Abstract.** Creation of composite building materials is a way of improvement of certain properties compared with such properties of source components as mechanical, physical, heat-insulating, acoustic, and in addition chemical stability, life span etc., or materials prime cost reduction, including at the expense of various waste utilization. In this connection, there is a lively interest in heat-insulating and acoustic insulation materials. In creating such materials the problem lies in an optimal solution concerning the choice of a light aggregate, binder and the simplest manufacturing technique for products of quite various shape and size. The advantage of a porous composite material is in unique combination of heat-insulating and structural properties and puts it on the same level with durable building materials designed for the same application. Many man-made formations, in particular solid waste, are valuable technological raw materials and can be involved in technological redistribution in order to obtain new composite building materials. In the production of crushed stone, sands from lithoid pumice and perlite, it is advisable to make the separation and separate obsidian. In this case, the separated obsidian turns into a production waste. Expansion of obsidian will make it possible to obtain a superlight large porous material and thereby solve environmental issues - to utilize production wastes. Concretes, produced using expanded obsidian, are of strength class B 12,5 and average density 1150-1200kg/m$^3$ can be called structural and superlight concretes based on expanded obsidians. Heat conductivity factor of such concretes of 400-1200 kg/m$^3$ average density varies from 0.125 to 0.35W/m$^0$K. Keywords: composite, expanded, obsidian, water, glass, temperature, average density, lightweight, concrete, aggregate, heat-insulating

## 1 Introduction

In the modern world, in many areas of human activity, new materials with a wide variety of properties are coming, an important advantage of these materials is the possibility of further improving the existing ones, creating new materials and technologies for their production by selecting raw materials, their ratio in a raw mixture, called a composite, and technological parameters. This enables to optimize the properties of these materials for

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specific operating conditions and expand the possibilities of their use by obtaining materials with a set of new technological and operational properties [1- 3].

Scientific and technological progress in the construction industry involves the use of new and effective building materials with a different set of properties, for various purposes. For a long time, the main building materials were wood, ceramics, steel, concrete and reinforced concrete. With the development of scientific and technological progress and the construction industry, new materials began to be intensively introduced into construction practice in the second half of the 20$^{th}$ century - composite building materials, without which the construction of most industrial, civil and residential complexes is impracticable today. The purpose of creating composite building materials is to improve certain properties in comparison with such properties of the original components as mechanical, physical, heat-insulating and acoustic, as well as chemical resistance, durability, etc., or to reduce the cost of materials, including also at the cost of utilization of various wastes. Composite building materials include: mortars, concretes, ceramics, mastics, adhesives, putties, paints and varnishes, fiberglass and other artificial multicomponent materials [1- 3].

Since composites are quite effective, their use in construction is quite common due to a number of advantages of these materials. The products are durable, some types of composite materials, for example, fiberglass, are able to compete with metal in their strength. Composites are distinguished by their lightness compared to analogs. Lightweight beams are much better suited for creating floors in large rooms than metal beams. These materials are highly resistant to aggressive environments, so not only internal structures can be created from them, but also used for external ones exposed to sunlight, precipitation and sudden temperature changes. Thanks to new technologies, modern composites have ceased to be fire hazardous, they do not allow the flame to spread, practically do not smoke and do not emit dangerous toxic substances [1- 4].

Many man-made formations, in particular solid waste from enterprises of the timber industry complex, metallurgical, mining and heat-and-power engineering industries, are valuable technological raw materials and can be involved in technological redistribution in order to obtain composite materials for structural purposes with the subsequent production of civil and industrial building materials from them.

In this connection, interest in new mineral thermal insulation and acoustic materials is growing. When creating such materials, the problem is to find the optimal solution for selecting a lightweight aggregate, a binder and the simplest technology for the production of items of the most diverse shapes and sizes.

The advantages of a porous composite material lie in a unique combination of heat-insulating and structural properties, and put it on the same level with durable building materials for the corresponding purpose. Many man-made formations, in particular solid waste, are valuable technological raw materials and can be involved in technological redistribution in order to obtain new composite building materials. Thus, in the production of crushed stone, sands from lithoid pumice and perlite, it is advisable to carry out separation and separate obsidian from the admixture. In this case, the separated obsidian turns into a production waste. Expansion of obsidian will make it possible to obtain a superlight large porous material and thereby solve environmental issues - to utilize production wastes [5].

## 2 Methodology

Conditioned by gradual common vein in many cases obsidian, perlite and lithoid pumice are met together. The quality of the lithoid pumice and perlite stock depends on the depth of the gally section, as far as parallel to the depth increases quantity of obsidian as admixture. Thus, the quantity of obsidian in perlites of various kind as a rule should not exceed 10 percent, however in production of lithoid pumice, crushed stone and sand the quantity of obsidian in lithoidal- pumice sand can reach 30 percent and more.

It has been experimentally proven that influence of obsidian on the concrete strength is "harmful", therefore, in production of crushed stone and sand from perlites and lithoid pumices it is expedient to make separation and extract obsidian from the admixture. The separated obsidian can be expanded and the obtained material can be used as aggregate for light concretes.

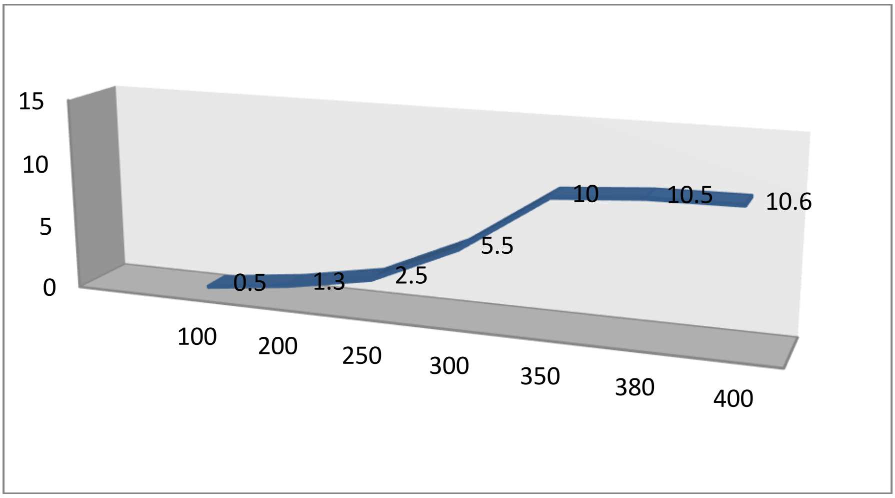
Expansion of obsidian is possible to implement at 1000-1200$^0$C. It has been found that due to the expansion of the obsidian, a light porous aggregate can be obtained of 200-1000kg/m$^3$ average density (Fig.1). To obtain aggregate of 200-350kg/m$^3$ average density the thermal treatment of grains having size of 5-20mm should be carried out at 1050-1150$^0$C during 3-10 minutes [5-8].

**Fig. 1.** Grains of expanded obsidian of different size and average density.

## 3 Results

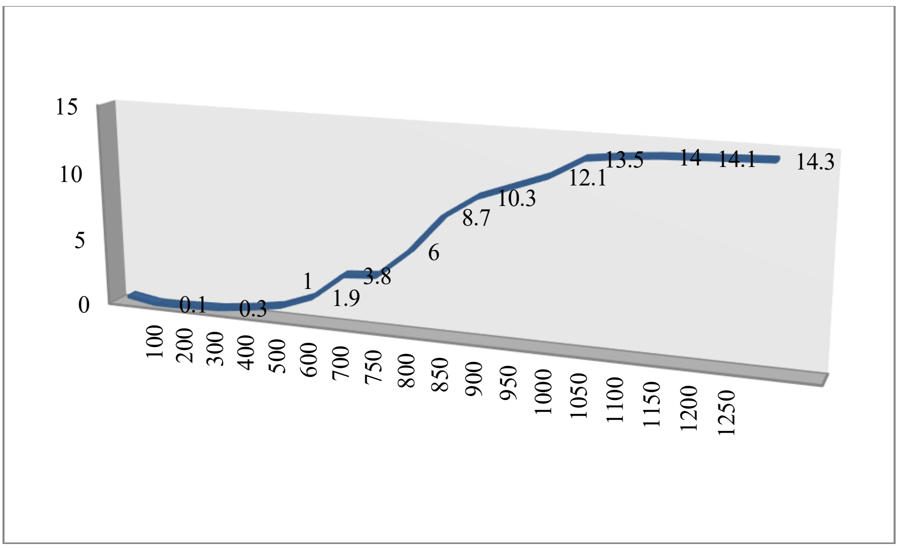
Depending on the obsidian average density of 200…1000 kg/m$^3$, compression strength varies within the range 4,5…19,1 MPa, porosity - 89…51 percent. It has been found that mechanical strength of the expanded obsidian is conditioned, in the first place, by the thickness of partitions. Water absorption ranges from 15.5 to 0.8 percent according to the mass. Water absorption of the light aggregate is conditioned by the structure of the expanded grain. Closed porosity provides minimum water absorption. The size of the grain substantially influences water absorption. By the reduction of expanded obsidian grains in the size, water absorption decreases. The factor of heat conductivity is equal to 0.44 – 0.11W/m$^0$K, such smallness of this factor is conditioned by that, that most of aggregate pores are closed. Loss of expanded obsidian mass after cold resisting property tests varies within 3,4…0,21 percent, such small loss is explained by that, that open pores quantity ranges from 8 to 20 percent. In such a case due to the jammed air in pores and capillars still remains a space where crystals of ice can penetrate during freezing period and exert essentially low pressure on partitions of pores, that is not to destroy them [5-8].

Studies have shown that for the light concrete obtained on the base of expended obsidian the optimal value of ultimate compression strength is achieved when for 1m$^3$ concrete mix 350…380 kg cement is consumed (Fig.2), maximum strength of light concretes corresponds to the average density which is equal to 900-1200kg/m$^3$ (Fig.3). From the above given dependencies it can be seen that the curve of the ultimate compression strength beginning from the 100kg cement consumption strictly rises and in case of 350-380kg its optimal value is obtained.




Ultimate compression strength, MPa Cement consumption, kg/m$^3$

**Fig. 2.** Strength of the light concrete depending on cement consumption, kg/m$^3$.




Ultimate compression strength, MPa Light concrete average density, kg/m$^3$

**Fig. 3.** Strength of the light concrete depending on the concrete average density.

To obtain light concretes on the basis of expanded obsidian in case when aggregate of up to 20mm size is used, the concrete under other equal conditions is obtained more homogeneous than when larger aggregate is used. In case of using porous aggregates with grains strictly differing in size, concretes can be obtained which are characterized by low average density and cement consumption. The strength of concrete with intergranular voids (Fig.3) depends on the strength of cement stone and the extent of intergranular voids which predetermine quantity of contacts between grains and the strength of the concrete. Regulating the extent of intergranular voids, we can also regulate the concrete strength. To obtain stronger light concretes (Fig.4) it is necessary to increase the quantity of fine grains, but in this case heavier concretes are obtained [5, 7, 8].

**Fig. 4.** Concretes with intergranular voids.

**Fig. 5.** Denser and heavier concrete blocks.

## 4 Conclusion

It has been experimentally proven that to obtain light concretes on the basis of expanded obsidian in case of using aggregates up to 20mm in size, the concrete under other equal conditions is obtained more homogenous, than in case of using larger aggregates. In case of strict difference in grains size, the obtained concretes are characterized by low average density and cement consumption. By regulating the extent of intergranular voids, we can regulate the strength and the volume weight of the concrete. To obtain stronger light concretes it is necessary to increase the quantity of fine grains, but in this case, heavier concretes are obtained. It has been found that the best index of strength of concretes obtained on the basis of expanded obsidian ranges from 350 to 380kg of cement consumption. It has been experimentally proven that insufficient and excess amount of water decreases the concrete strength.

Concretes obtained on the basis of expanded obsidian and having B12,5 strength and an average density within 1150-1200kg/$m^3$, can be called structural and superlight concretes on the basis of expanded obsidian. Thermal conductivity factor of concretes with an average density ranging from 400 to 1200kg/$m^3$ varies from 0.125 to 0.35W/$m^0$K.

The expansion of obsidian enables to obtain a superlight popcorn material. On the basis of expanded obsidian can be obtained new effective composite heat-insulating material having high operational properties and widen assortment of effective building composite materials.

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