BG Pulse Journal USA
ISSN:1947-2536 http://www.bgpulseusa.com/index.php/bg
BG PULSE JOURNAL

UDC 666.973.6

MICROSTRUCTURAL FEATURES OF DIFFERENT TYPES OF LIGHTWEIGHT CONCRETE

Soy V.M., Eshbekov Sh.G., Turgaev J.A.

Abstract

This thesis discusses the microstructural features of the main types of lightweight concrete: foam concrete, aerated concrete, concrete with expanded vermiculite, and wood-cement concrete (arbolite). It is shown that the service properties of lightweight concretes are determined not only by their average density, but also by the character of the pore structure, the shape and distribution of pores, the condition of the interfacial transition zone, and the strength of the cement matrix. Foam concrete is characterized by rounded air pores formed by pre-produced foam; aerated concrete has a developed system of gas macro- and micropores with a calcium silicate hydrate structure; vermiculite concrete contains lamellar particles of expanded vermiculite in the cement matrix; and arbolite contains an organic aggregate surrounded by cement paste. It is concluded that targeted regulation of microstructure can improve the strength, thermal insulation properties, and durability of lightweight concretes.

Keywords

Lightweight concrete, foam concrete, aerated concrete, expanded vermiculite, arbolite, microstructure, porosity, cement matrix, thermal insulation materials.

Introduction

Lightweight concretes occupy an important place among modern construction materials used to reduce the weight of envelope structures, increase the energy efficiency of buildings, and decrease the load on load-bearing elements. This group includes foam concrete, aerated concrete, concretes based on porous mineral aggregates, and organomineral composites such as arbolite. Despite differences in composition and production technology, these materials share a developed pore structure that determines their density, thermal conductivity, strength, and durability.

The aim of this thesis is to provide a comparative characterization of the microstructure of foam concrete, aerated concrete, concrete with expanded vermiculite, and arbolite, and to show the effect of the pore system and interfacial transition zone on the service properties of these materials.

Main part

Foam concrete is a cellular concrete in which the porous structure is formed by introducing pre-produced technical foam into a cement-sand or cement-ash mixture. Its microstructure contains rounded air pores separated by thin partitions of hardened cement paste. For foam concrete, not only the total pore volume is important, but also the thickness of the inter-pore walls, the uniformity of pore distribution, and the composition of the solid phase. Uniform pore formation reduces average density, while a dense cement matrix helps provide sufficient material strength.

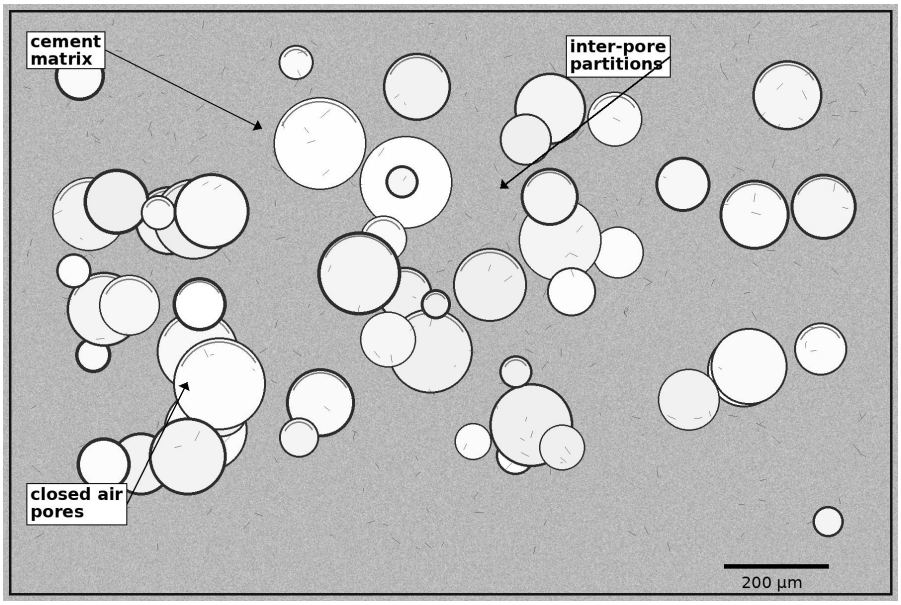


Figure 1 - Schematic SEM-like image of the microstructure of foam concrete

Aerated concrete differs from foam concrete in its pore-forming mechanism: pores are generated as a result of gas release, most often during the reaction of aluminum powder with the alkaline medium of a cement-lime mixture. During autoclave curing, calcium silicate hydrate products, including tobermorite, form in the structure of aerated concrete and affect its strength and stability. The microstructure of aerated concrete is characterized by a combination of large gas pores, capillary pores, and a fine calcium silicate hydrate matrix.

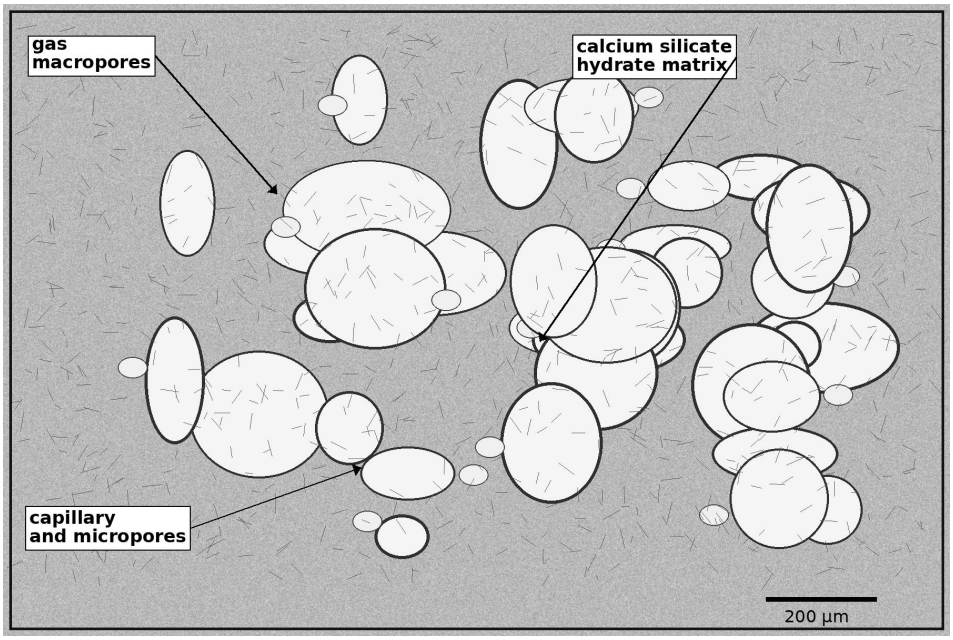


Figure 2 - Schematic SEM-like image of the microstructure of aerated concrete

Concrete with expanded vermiculite belongs to lightweight thermal-insulating concretes based on a mineral porous aggregate. Expanded vermiculite has a lamellar structure, low bulk density, and high heat resistance. In the cement matrix, its particles act as a lightweight aggregate that reduces

density and thermal conductivity. The microstructure of this concrete is characterized by plate-like vermiculite grains, pores between particles, and an interfacial transition zone between hardened cement paste and vermiculite.

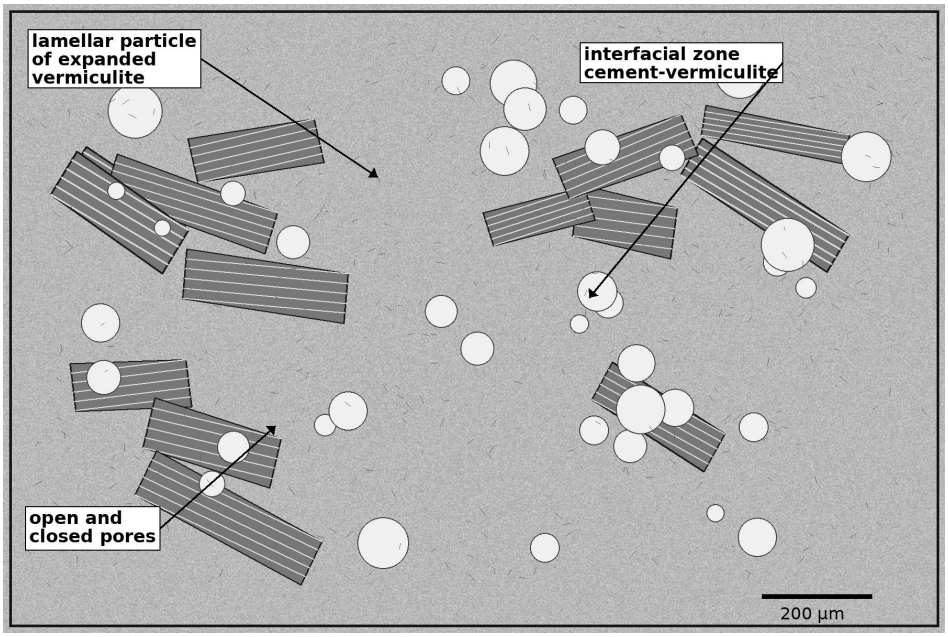


Figure 3 - Schematic SEM-like image of the microstructure of concrete with expanded vermiculite

Arbolite is a lightweight concrete based on an organic aggregate, most often wood chips or other plant residues. Its microstructure differs fundamentally from foam concrete and aerated concrete because porosity is created not only by air voids but also by the structure of the organic aggregate itself. In arbolite, the cement matrix should uniformly coat the wood particles, providing adhesion and protecting the aggregate from moisture and biological damage. The strength of arbolite largely depends on the quality of mineralization of the organic aggregate and the density of the interfacial transition zone.

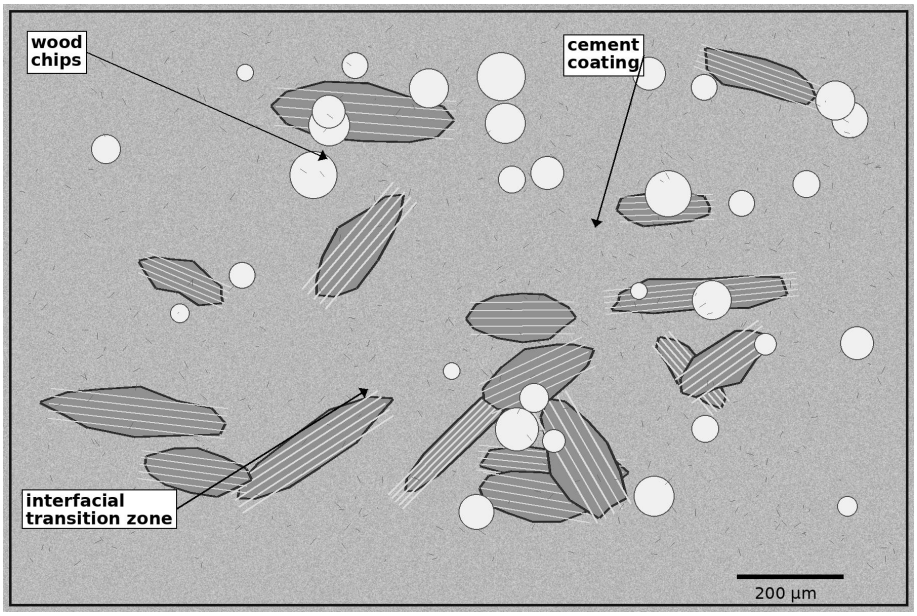


Figure 4 - Schematic SEM-like image of the microstructure of arbolite

Comparative characteristics of the microstructure

Type of lightweight concrete	Main method of pore formation	Key microstructural elements	Advantage	Limitation
Foam concrete	Introduction of pre-produced foam	Rounded pores and cement inter-pore partitions	Low density and technological simplicity	Sensitivity to foam stability and curing conditions
Aerated concrete	Gas release in an alkaline medium	Gas macropores, capillaries, and calcium silicate hydrates	High thermal insulation capacity	Requires accurate gas-forming agent dosage and curing regime
Concrete with expanded vermiculite	Use of a porous mineral aggregate	Lamellar vermiculite grains and the cement-vermiculite contact zone	Thermal insulation and heat resistance	High water absorption of the aggregate
Arbolite	Porosity of the organic aggregate and cement matrix	Wood chips, cement coating, and interfacial transition zone	Eco-efficiency and use of plant waste	Requires mineralization and protection of organic aggregate

Conclusion

The microstructure of lightweight concretes is the main factor determining their physical, mechanical, and thermal insulation properties. Foam concrete is effective due to its uniform system of air pores; aerated concrete due to its developed porosity and calcium silicate hydrate structure; concrete with expanded vermiculite due to its lamellar mineral aggregate; and arbolite due to the combination of a cement matrix and organic aggregate. The most promising direction is the control of the pore structure, interfacial transition zone, and composition of the cement matrix, which makes it possible to obtain lightweight concretes with reduced thermal conductivity, sufficient strength, and increased service stability.

Note on the figures

The presented microstructural images are scientific schematic SEM-like illustrations prepared to explain the material structure. They are not laboratory electron microscopy results for specific specimens.

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