BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LI (LV), Fasc. 1–2, 2005
CONSTRUCŢII. ARHITECTURĂ

TYPES AND CHARACTERISTICS OF PREFORMING CONCRETES USED IN THE CONSTRUCTION PROCESSES ENGINEERING

BY

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The light concrete industry has a great development at present, due to some technical characteristics that make them highly appreciated. These characteristics are: the reduced apparent density, the capacity of high thermal insulation and high resistance at fire, compared to the heavy concretes. These features have as result a type concrete elements (simple, reinforced or prestressed) with reduced weight, which are good thermo-insulators and easy to manufacture, etc.

1. Light Concretes

By " light concrete " we mean that type of concrete that has the apparent density, $\rho_b < 1,700$ kg/m^3.

A classification of light concretes can be done:

a) accordingly to structure and granulosity: compact, macro-porous, cellular;

b) accordingly to the type of the aggregates used: mineral aggregates, vegetative aggregates, organic polymeric aggregates;

c) accordingly to the main field of use: thermo-insulator concretes, thermo-insulator and strength concretes, strength concretes.

The functional classification of the light concretes according to the Euro-International Committee of Concrete (E.C.C.) and the F.I.P. - E.C.C. colloquium in Copenhagen is summarized in Table 1.

The aggregates used in the preparation of the light concretes are normal heavy aggregates (in the case of the macro-porous concretes) and, especially, porous light aggregates. The light aggregates are inorganic (mineral), organic or natural (the vegetative ones) and artificial (the polymeric organic ones); the bulk density of the light aggregates is less than 1,200 kg/m^3. At the preparation of the light concretes are mainly used the light mineral aggregates, which may be classified in:

a) natural aggregates (diatomaceous earth, volcanic tuffs, basaltic cinders, etc.);

b) artificial aggregates, which are industrial secondary products, like the boiler slag, the burnt steril from the coal mining, the ceramic sweepings, etc., products manufactured in a special way like the expanded clay, the expanded blast-furnace slag, the expanded perlith, etc.

Table 1
Functional Classification of the Light Concretes

Type of the light concrete	Apparent density in dry state,[kg/m^3]	Compression strength N/mm^2	The coefficient of thermal conductivity
Light concrete of strength (structure)	1,600...1,900	30...70	0.6...1.0
Light concrete of strength and thermal insulation	1,300...1,600	15...20	0.5...0.8
Thermal insulator light concrete	$<1,450$	<15	<0.75

According to the bulk density, in refining condition of the dried material, the light mineral aggregates may be divided into the classes indicated in Table 2; the bulk density is defined on the 7/16 mm type, while for the aggregates which have the maximum granulosity of 7.1 mm, the definition is made on proper material.

Table 2
Classification of the Light Aggregates

Class	Subclass	Density ρ_{ga}, [kg/mm^3]	Types of aggregates
A_1	A_{1a}	<200	expanded perlith
	A_{1b}	201...350	expanded perlith, granolith
A_2	A_{2a}	351...500	diatomaceous earth, granolith
	A_{2b}	501...600	granolith, expanded slag
A_3	A_{3a}	601...750	granolith, expanded slag, agloporith
	A_{3b}	751...900	granolith, expanded slag, basaltic cinder, boiler slag
A_4	A_4	901...1,200	basaltic cinder, dacite tuff, burnt steril, ceramic pieces

The most used light aggregate is the expanded and granulated clay, which also has the name of granolith.

The granolith is obtained as a result of the expansion of the easily fusible clays. For this purpose the clay is shaped as granules with reduced quantities of water and is burnt inside rotary kilns at a temperature of 1,100°...1,200°C.

The possible sorts for the granolith to be delivered are: 0/7.1 mm, 7.1/16 mm, 16/31 mm and are part of the subclasses A_{1b}, A_{2a}, A_{2b}, A_{3a}, A_{3b}. The crushing strength of the granolith has to be minimum: A_{2a} – 2 N/mm^2; A_{2b} – 2.5 N/mm^2; A_{3a} – 3 N/mm^2; A_{3b} – 4 N/mm^2, based on the bulk density in a refining and dried condition.

The expanded slag is obtained by cooling the blast-furnace slag in the expansion tank with powerfull water jets; the aggregates of the expanded slag are obtained by crushing and sorting the expanded slag. These aggregates are delivered in sorts of 0/7.1 mm, 7.1/16 mm and 16/31 mm, having the densities situated in the range 500...1,200 kg/m^3.

The concretes with expanded slag have the medium densities of 2,000 kg/m^3 on classes that vary between 15 and 25 N/mm^2 and are being used at the manufacture of small blocks for masonry, as well as for the large panels, which are used in the construction of the buildings.

The expanded perlith is a very porous material with the density in mass under 350 kg/m^3.

The agloporith results from the burning of the industrial refuse with coal content, like the slag and the ashes from a power-station, as well as the burnt steril from the coal mines; it has the compression strength of 1...5 N/mm^2.

2. Compact Light Concretes

These concretes are manufactured with light mineral aggregates and vegetative aggregates. The main characteristic of their structure is their compactness, which is obtained by completely filling with mortar of the holes between the granules; the reduced weight of these concretes is exclusively due to the porosity of the aggregates.

These light concretes, also called "strength concretes" or "structural concretes", are used in the manufacture of the supporting and non-supporting elements (panels) of the several floors buildings, of the elements for the roofs of the industrial buildings, the buildings used for sportive and social-cultural activities; they are used as well for bridges and viaducts.

The composition of the light concretes with granolith is established based on preliminary tests, as in the case of the normal concretes. When establishing the composition of this concrete there will be considered the following factors:

a) the sum of the percentage of normal sand 0/3.15 mm and the percentage of the three types of granolith is 100;

b) the quantity of cement plus the quantity of 0/3.15 mm ballast pit sand has to be of minimum 500 kg/m^3 for the concrete of type $\leq$ BG 300 and 600 kg/m^3 for the concrete of type BG 400...BG 450;

c) the apparent density of the aggregates granules, as well as the real density of the cement needed in establishing the doses of the materials for 1 m^3 of concrete can be either experimentally determined or can be established using the following values: the ballast pit sand 0/3.15 mm – 2.5...3.0 kg/dm^3; granolith 0/3.15 mm – 1.9...2.2 kg/dm^3; granolith 3.15/7.1 mm – 1.4...1.7 kg/dm^3; granolith 7.1/16 mm – 1.3...1.65 kg/dm^3; cement – 3.1 kg/dm^3.

The technical characteristics of the compact light concretes are varied according to the nature and the quantity of the composing materials. The main mechanical characteristic, the compression strength, R_b, is influenced by the composition factors of the light concrete.

The compression strength of the concrete grows with the increase of the cement's amount and the improvement of the cement's quality.

The stretching resistance of the light concrete is generally smaller with 10...30% than that of the normal havy concrete from the same class; this fact is due to the direct influence of this solicitation, to the reduced resistance of the aggregate (the breaking takes place inside the aggregate) and to the decisive action of some factors from the ambient (humidity, temperature).

The modulus of elasticity, E_b, which is the basic parameter for the appreciation of the deformations that take place under the loads of the concrete, can be established relying on the apparent density and the compression strength, following the relation

$$E_b = K\sqrt{\rho_b^3 R_b(R_{\text{cyl}})},$$

where: ρ is the apparent density of the concrete, [t/m^3], [kg/dm^3]; $R_b(R_{\text{cyl}})$ – the compression strength on cubes (cylinders), [kgf/cm^2]; $K = 4{,}000$ according to Pauw; 4,270 according to A.C.I.; 6,000 according to E.C.C.

The elasticity modulus of the light concrete is approximately 1/3...2/3 from the modulus of elasticity of the normal concrete, from the same class.

The contraction of the light concrete with granolith is usually smaller than the contraction of the heavy concrete during the first 100 days; after this period the contractions are almost equal; the smaller values of the light concrete contraction have a variable effect on the behaviour of the construction elements.

The thermal conductivity of the compact light concrete depends on different factors; the greatest influence is that from the apparent density, the type of the aggregate and its structure, as well as the relative humidity. Regarding the humidity it has been noticed the fact that the thermal conductivity increases at the same time with the increase of the humidity.

3. Macro-porous (Semi-compact) Concretes

These concretes are obtained by choosing a special granulosity of the aggregates that can be either heavy compact or light porous. The fine part from the aggregates is eliminated partially or totally and the quantities of cement and water are dosed so that each granule should be covered with a fine film of cement past, without filling the empty spaces between the granules. The conclusion is that the dosage of cement has to be calculated so that the cement paste covers the aggregates granules in film, joining them only in the contact points.

The macro-porous concretes are of various types based on the volume of the holes (V_g); they have:

a) type A, with $V_g = 25...35\%$; it is made with monogranular aggregates, either heavy or light, in only one sort;

b) type B, with $V_g = 20...25\%$; it is realized with heavy or light aggregates made of several sorts;

c) type C, with $V_g < 20\%$ and having more sorts of light aggregates; it is also allowed a small percentage of the fraction 0...3 mm.

The mechanical strengths of these concretes depend on the same factors as in the case of the normal heavy concrete, with values up to 10 N/mm^2 at compression.

The thermal conductivity of the macro-porous concretes is higher than that of the compact light ones with the same density, and this is because of the pores that are larger. These concretes have a high permeability as well as a high resistance to freezing and defrosting actions due to the holes that allow water to pass through, playing the role of some expansion vessels where the water gets frozen.

The macro-porous concretes are used for small and large blocks in masonry, thermo-insulating concrete resurfacing and structures for large panels, thermo-insulating plates, as well as for filling and equalizing layers and drainages; they are used as replacement for the classical inverted filters in the hydrotechnical constructions.

4. Cellular Concretes

The cellular concretes are materials which have a lobe-like structure and contain around 50% (in volume) closed pores with spherical shape and the diameter of cca. 1 mm; they are uniformly distributed in the mass of the concrete.

The porous structure of the cellular concretes is obtained either by provoking a chemical reaction followed by a dispersal of gases in the fresh mixture – concrete with gas – or by mixing the mortar with foam (foam-concrete).

The advantages of this type of concrete are: the reduced apparent density, the superior thermotechnical characteristics, a good resistance at fire; they also can be processed and manipulated with simple instruments; all these plus the mechanical characteristics make this concrete widely used. It also has some disadvantages, like: a large absorption of water, which makes the concrete difficult to use when humidity unless there is some barrier against the vapours; they also have a reduced resistance to successive actions of freezing or defrosting; they have a high contraction (cca. 5 mm/m) and the armatures and metallic pieces included in their mass are exposed to corrosion unless protected.

The constituent materials needed in the production of the cellular concretes are:

a) the binder, which is the Portland cement, preferably without any other additions; the lime has to be finely grinded;

b) the aggregates used, which are the river sand or the pit sand, the power station ash, the diatomaceous earth.

The gas generator substances are of different types based on their chemical reaction namely:

a) elements like Al, Zn, Mg or the ferro-alloys Fe – Si, Fe – Mn, which, as powders, react with the basic constituents of the binder, forming hydrogen;

b) substances that react with each other producing gases;

c) substances that decompose by oxide-reducing reactions producing gases.

The foam generating substances have to ensure the formation of a quantity of stable foam with fine pores, which doesn't get destroy when mixed with mortar and it doesn't negatively influence the binding and hardening processes of the binder. The foam gnerators are: foaming agent, glue and colophonate soap, naphta sulphate-aluminates, etc. The foam stabilizers are: aluminium and iron salts, glue, starch, calcium chloride and plasticizers.

As auxiliary materials are used chemical reactions accelerators (soluble glass, calcium chloride), retarding admixture (plaster, sugars), pore stabilizers.

Due to the fact that the cellular concretes get hardened by autoclavization they are named *autoclaved cellular concretes* (A.C.C.).

The technical characteristics of the A.C.C.'s are: a) the compression strength is especially influenced by the density, increasing with it but not in a proportional way; b) the compression strength gets low when there is high humidity. In order to calculate the value of the A.C.C.'s compression strength is used the relation:

$$\overline{R}_c = (0.05...0.0005\overline{R})\overline{R}, \quad [\text{kgf/cm}^2],$$

where: $\overline{R}_c$ is the design strength of compression; $\overline{R}$ – the mark determined on a 10 cm - side cube

Received, May 9, 2005

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TIPURILE ŞI CARACTERISTICILE BETOANELOR PERFORMANTE
UTILIZATE ÎN INGINERIA PROCESELOR DE CONSTRUCŢII

(Rezumat)

Betoanele uşoare cunosc o mare dezvoltare în prezent datorită unor caracteristici tehnice care le fac deosebit de apreciate: densitate aparentă redusă, capacitate de izolare termică ridicată şi rezistenţă la foc sporită, în comparaţie cu betoanele grele. Aceste caracteristici conduc la elemente din beton cu greutate proprie redusă, uşor de prefabricat etc.