Innovation Concrete Laboratory

K1 ICL-PS-LWC

"Research - Development - Optimization"

It is known that one of the most significant concrete types based on the field of construction is lightweight concrete with a certain amount of polystyrene (EPS) beads, which has thermal insulation and load-bearing properties. Polystyrene lightweight concrete is a type of concrete that contains expanded polystyrene beads, water, sand, cement, and light additives. The simplest representative of this type of concrete is lightweight concrete with a grain gap, which is used primarily as a thermal insulation system, as an additional construction technology (production of layered technologies, “sandwich panels”). The main features of these systems are low and medium density and relatively low flexural and compressive strength, but their thermal insulation is excellent. A significant disadvantage of their applicability is the low flexural and compressive strength and the fact that they cannot be using steel insert, so their use as structural and monolithic elements can only be carried out under special conditions. The widest possible use of this type of concrete requires significant costs in terms of the additives used, so it can be said that there are currently two uses in industry: relatively cheap but non-load-bearing joint fillers (low density and cement content with high EPS content).) and the production of load-bearing but non-structural-material masonry units (high density and medium cement content with medium EPS content). Various lightweight concretes are increasingly used in the manufacture of floors and ceilings, as well as as space-filling materials, but in many cases masonry elements and structural elements have already been made from this type of concrete. The main disadvantages of the technologies currently used in the industry and their limitations according to standards:

- they are practically not - or only to a limited extent - steel-reinforcing, thus significantly limiting the use of PS lightweight concrete in the production of monolithic concrete and panel and structural elements

- practically non-existent - or only to a limited extent - fiber-reinforced, because the use of these materials can significantly affect the silicate chemical processes at the silicate-polystyrene-bead-plastic fiber and silicate-plastic fiber interface

- at medium and high cement content (> 400-600 kg) the shrinkage of the finished concretes is significant

- even at medium and high cement content (> 400-600 kg) the compressive and flexural strength of the finished concretes is relatively low
- even with medium and high cement content (> 400-600 kg) it is necessary to use various additives and a high degree of optimization to achieve the appropriate compressive strength and concrete technology characteristics
- the use of different admixtures is only possible to a limited extent, because the stability of polystyrene lightweight concrete systems can be significantly affected
- achieving the appropriate concrete technology characteristics can lead to a significant increase in cost, as a result of which the use of these systems and materials may be pushed into the background

In view of the above, we aimed to develop an admixture composition that can be used to favorably modify the concrete technology characteristics of both low cement and high EPS bead concretes and medium (as well as high) cement and low polystyrene building materials. . Building on the use of ICL admixture, we have developed a technology that allows the use of large quantities of plastic waste grind (PET, LDPE, HDPE, PP, PE) and the use of steel inserts in the production of various concretes.

The table below shows the characteristics of some commercially available PS lightweight concrete. For concretes from other manufacturers and distributors, Ref.1, Ref.2, etc. referred to as, the names used to denote self-developed PS lightweight concrete mean:

- ICL-PS-LWC-mixture1: low (medium) cement content and high PS content lightweight concrete made with 4 admixture and K1-CA solid admixture.
- ICL-PS-LWC-mixture2: high cement content and medium PS content lightweight concrete with 4 admixtures and K1-CA solid admixture.
- ICL-PS-LWC-Basic1: lightweight concrete with low (medium) cement content and high PS content made with K1-CA solid admixture.
- ICL-PS-LWC-Basic2: lightweight concrete with high cement content and medium PS content made with K1-CA solid admixture.

Type of LWC	Density (kg/m^3)	Amount of PS-beads (L)	Amount of cement (kg)	Compressive strenght (MPa)	Flexural strenght (MPa)	Doping of PP-fiber	Using of steel-inserts	Price (Ft;+ÁFA)
Ref.1	~1000	~800	~400	~2,8	~0,2	x	x	~20.000
Ref.2	~1400	~550	~700	~6,4	~1,2	x	x	~28.000
Ref.3	~1000	~950	~400	~8,2	~1,3	✓	x	~46.000
Ref.4	~1600	~450	~800	~12,6	~1,8	✓	✓	~44.000
ICL-PS-LWC-mixture1	~830	~1000	~400	~6,5	~3,2	✓	✓	~42.000
ICL-PS-LWC-mixture2	**~1515**	**~450**	**~800**	**~24,5**	**~4,1**	✓	✓	**~44.000**
ICL-PS-LWC-Basic1	~802	~1000	~400	~6,1	~2,6	✓	✓	~32.000
ICL-PS-LWC-Basic2	**~1636**	**~450**	**~800**	**~24,6**	**~3,5**	✓	✓	**~36.000**

Notes:

- graded sand fraction with a nominal size of 0/4 mm was used in the preparation of ICL lightweight concretes (grain distribution: GF85, clay sludge content <3%)
- for fracture tests of 150 * 150 mm specimens made of ICL lightweight concrete, rotating the already broken specimens by 90 ° gives 85-95% of the original fracture result
- the raw materials and admixtures used for ICL lightweight concretes comply with the requirements set out in the current European Union and Hungarian standards (EN 206: 2013 and MSZ 4798: 2016)
- ICL lightweight concretes were prepared in compliance with the concentration ranges specified and permitted in the European Union standards (2%)

The use of ICL-CA and ICL-technology can significantly increase the compressive and flexural strength of PS lightweight concretes, and produce concretes with excellent watertightness and frost resistance. By using the solid ICL-CA, it is possible to make lightweight concrete with any PS content ironable by means of prestressed iron structures or

edited steel inserts. The application of the technology allows the use of a certain amount of plastic waste grid to improve other characteristics (thermal conductivity, watertightness, flexural strength) of PS lightweight concretes, thus enabling the development and application of environmentally conscious manufacturing technology. Due to the special composition of the additive, PE, PP, HDPE, LDPE plastic-based wastes can be used, but by combining certain components of the additive, PVC, PVP, PVAC-based materials can also be processed as construction raw materials.

With the help of the ICL-CA - and the technology based on its use - the following advantageous features can be observed on PS lightweight concrete systems:

- With the same concrete technological characteristics (compressive strength, watertightness), a significant - up to 30-45% - weight reduction can be achieved for each concrete and panel element compared to clay pebble or coarse-grained gravel concretes.
- PS-lightweight concretes prepared with the help of ICL-CA have excellent shelf life, pumpability and workability, therefore they can be used as monolithic concrete.
- In the case of concretes made with ICL-technology, the application concentration of the admixture - due to its chemical properties - can be applied above the range of 2-5%, they can show a further significant improvement in the concrete technological properties.
- With the application of the admixture, pre-assembled, welded or prestressed steel inserts can be used practically from low and medium cement lightweight concretes in various applications of PS lightweight concretes.
- ICL-technology makes PS lightweight concrete suitable for the use of relatively large amounts of plastic waste in the form of fiber chips.
- By using ICL-technology, a significant improvement in concrete technology can be achieved in the production of ready-mixed concrete, in the production of masonry and block elements as well as panel elements.

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