Scientists come up with nanoconcrete for casting under negative temperature conditions

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A close-up view on huge scaffolding at the construction site for building the new Municipal Library. At the left the thick layers of scaffolds are necessary to support the forward horizontally front-facade. Credit: Fons Heijnsbroek (@fonsheijnsbroek51), Unsplash

Engineers from Far Eastern Federal University Military Training Center (FEFU, Vladivostok, Russia) together with colleagues from RUDN University have developed a concrete mixture with nano additives for monolithic construction up to ten stories high. The concrete casting is possible within a very humid climate and negative temperature down to minus 5-degrees centigrade. Given that, the constructed buildings will not require major renewal for 50 years. The related article is published in *Construction and Building Materials*.

Casting concrete under low-temperature conditions is a serious challenge for the construction industry. If the water in the concrete freezes, the fluidity of the concrete goes wrong, which will foul its curing and promote in-slab lumps forming. Casting at temperatures below plus five degrees already requires special technology. Breach of one leads to reduced characteristics of monolithic structures that deteriorate prematurely.

Engineers of the FEFU Military Training Center (MTC), together with colleagues from RUDN University, suggested introducing into the concrete mix special additives (super plasticizers) whose properties are improved via nanotechnology. The development helps to maintain the strength and durability of concrete structures erected during the cold season, not to make the construction process more expensive.

"The characteristics of the new nano mixture meet the needs of civil engineering and generally exceed regulatory requirements. The mixture is suitable for casting of civil structures up to 10 stories high under humid conditions. That makes it relevant for construction in humid continental, monsoon, and moderately cold climates. The mixture is curing quickly and the concrete slab produced has a dense structure with no lumping and with a pore size smaller than in conventional concrete.

Thus, moisture, which destroys ordinary concrete, is not capable of penetrating the new one. The properties of the concrete slab remain unchanged for 50 years." Explained one of the research authors Roman Fediuk, Lt. Col., professor at the FEFU MTC, the winner of the XIII All-Russian contest "Engineer of the Year 2018."

The scientist went on to say that the new concrete mixture, like previous developments, contains less cement, replaced with ash from energy production and screenings of crushing sand that makes the concrete environmentally friendly. Within that, the technological properties of the new mixture are the same as of the mixtures containing high-grade cement, which makes the development more cost-effective.

Engineers found out the proportions of the modified additives empirically; after that, mathematical models refined the calculations. The mixture with such a verified composition resists frost and has no increased fluidity, causing at low temperatures in-slab lumping of concrete (segregation) and a decrease in the strength of the cast structure. Moreover, engineers used up to 40 percent less water in the mixture, and increased the strength and density of concrete slab. High density and gel pore size were achieved not only because of nano-additives but also due to the technology of additional grinding of concrete particles. A grinder was also developed at FEFU.

The new mixture has already undergone a test drive. As field research, engineers built a five-story parking lot. The concrete was cured for 28 days under natural conditions with temperature differences from plus five to minus six degrees, and the results were in accordance with the stated standards.

As additives, scientists used components already well known in the construction industry, the properties of which they improved with nanoparticles. Thus, they have strengthened naphthalene formaldehyde

resin by the properties of silicon dioxide, and the resulting concrete turned out to be stronger while maintaining operational characteristics longer. Saponified wood resin and sodium nitrate also are components of the mixture.

A scientific school for the development of intelligent composites for special and civil engineering takes place at the FEFU MTC. The main idea of the school is to design artificial materials similar to natural ones. For example, concrete should have the strength of natural stone. This theory is taking hold in modern science as geonics (geomimetics) established by professor Valery Lesovik of V.G. Shukhov Belgorod State Technological University, a corresponding member of the Russian Academy of Architecture and Construction Sciences. Engineers from Moscow, Kazan, and the Russian Far East are working on the development of the method. The new concrete design is in accordance with the principles of geomimetis, the ultimate goal of which is to design new materials for a comfortable human environment.

At the next stage of research, scientists plan to develop a concrete mixture for casting under negative temperatures down to minus fifteen degrees centigrade.

More information: Alexander P. Svintsov et al, Effect of nano-modified additives on properties of concrete mixtures during winter season, *Construction and Building Materials* (2019). DOI: 10.1016/j.conbuildmat.2019.117527

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