P R O G R A M INTERNATIONAL WORKSHOP-CONFERENC

NANO-CEMENTS — FUTURE OF WORLD CEMENT INDUSTRY AND CONCRETE TECHNOLOGY

DUBAI, THE UAE, Habtoor Grand Beach Resort & Spa Autograph Collection

Seminar Organized by:

Mr. **Khasanov Nail**

Languages of seminar-conference:

Russian, English and Arabic

April 6

09:00 – 10:00 **Registration of participants and provision of seminar-conference materials — in the entry hall of the** Habtoor Grand Beach Resort & Spa Autograph Collection.

10:15 – 11:00 **NANO-CEMENTS — FUTURE OF WORLD CEMENT INDUSTRY AND CONCRETE TECHNOLOGY.**
Contributor — BICKBAU MARCEL, Academician of Russian Academy of Natural Sciences, New-York Academy, and others, Doctor of Chemical Sciences.

11:00 – 12:00 BICKBAU MARCEL Answers to the questions.

12:00 – 12:45 **REVOLUTION OF CEMENT AND CONCRETE TECHNOLOGIES. THE PRELIMINARY STANDARD - NANOMODIFIED PORTLAND CEMENT IS APPROVED IN RUSSIA.**
Contributor — BICKBAU MARCEL, Academician of Russian Academy of Natural Sciences, New-York Academy, and others, Doctor of Chemical Sciences.

12:00 – 12:45 BICKBAU MARCEL Answers to the questions.

13:00 – 14:30 DINNER.

14:30 – 15:30 **NANO-CEMENTS AND CONCRETES ON THEIR BASE TESTS IN THE U.S, P.R. CHINA, THE UAE, SAUDI ARABIA, PORTUGAL AND BRAZIL.**

15:30 – 16:30 Answers to the questions.

16:30 – 17:00 **ECONOMY EVALUATION OF THE NANO-CEMENT PRODUCTION MANAGEMENT.**

17:00 – 17:30 Answers to the questions.

April 7

10:00 – 10:30 **ENERGY SAVING AND ECOLOGICAL COMPATIBILITY OF NANO-CEMENT PRODUCTION.**
Contributor — KHASANOV NAIL

10:30 – 11:00 KHASANOV NAIL Answers to the questions.

11:00 – 11:30 **CONDITIONS FOR PRACTICAL REALIZATION OF CONTRACTS AND AGREEMENTS CONCERNING THE TRANSFER AND DEPLOYMENT OF NANO-CEMENT TECHNOLOGY.**
Contributor — BICKBAU MARCEL, Academician of Russian Academy of Natural Sciences, New-York Academy, and others, Doctor of Chemical Sciences.

11:30 – 12:00 BICKBAU MARCEL Answers to the questions.

12:00 – 13:30 Discussion of seminar-conference participants (Anybody who wants to participate).

13:30 – 15:00 DINNER.

15:00 – 17:00 Work on the contracts and agreements with seminar-conference participants.

17:00 – 18:00 Signing of contracts and agreements.

18:00 – 20:00 FURSHET.

NANO-CEMENTS — FUTURE OF WORLD CEMENT INDUSTRY AND CONCRETE TECHNOLOGY

Bickbau M.Ya.,
Academician of Russian Academy of Natural Sciences, Doctor of chemical sciences, Director General of Moscow Institute of Material Sciences and Enabling Technology IMET, Public Corporation

Invention of cement and concrete is a remarkable achievement of humanity that gave the opportunity to create an industrial building of housing and engineering constructions, main transport routes. Everything that we build on the planet is made with Portland cement, the annual output of which is more than 3.8 billion tons. The concrete annual production on the base of Portland cement exceeded 15 billion tons and continued to increase rapidly: concrete dams and arterial roads, piers and aerodromes, bridges and stadiums, television relay towers and skyscrapers, many billions of square meters of housing construction every year.

The production of such a great amount of cement annually requires burning of more than 500 billion tons of fuel and comes amid high rate of heat release, NOx, SO2 and CO2 that contribute to climate change on the planet. Just only CO2 emission released into the atmosphere by cement plants is approximately 850 kg per each cement ton. Annually it is equal to more than 3 billion tons or 70 billion square meters in the form of gas. Every year dozens of new enterprises are added to existent thousands of cement plants in P.R. China, India, Latin America and other developing countries; amounts of cement transportation also increase.

This report describes the outstanding achievement of new possibility - modification of Portland cement into nano-cement. It allows to overview the development strategy of the world cement industry and today gives the opportunity to get additionally more than 2 billion tons of cement:
- without any construction of new cement plants for burning of cement clinkers;
- without any necessity to open new limestones and clays quarry;
- without fuel burning and air pollution by NOx, SO2 and CO2 emissions, and also dust and heat;
- transforming the great amount of accumulated man-made wastes — slags, ashes, processing wastes of stone, which deteriorate planet ecology, and unused, unsuitable for building, fine-grained desert sands and widely used sand quarries into high-quality cement;
- with better cement conservation to over a year, costs reduction of cement production and its transportation;
- with the improvement of quality and useful life of concrete, doubled or tripled costs reduction of Portland cement in ready-mix concrete by costs reduction of their production.

Evidence from P.R. China, the largest cement industry in the world develops rapidly. Chinese industry reached the top position in cement production. If in 1990 cement industry amounted 210 million tons, in 2012 it was already 2.18 billion tons, and in 2014 cement production in P.R. China was evaluated at 2.5 billion tons that corresponded 70% of world production.

Chinese cement industry accounts for more than 8% of world industrial consumption of energy, and also more than 13% of the total amount of CO2 emissions. In 2012, export of cement from China was 11.997 million tons and increased by 13% to 2011.

Cement industry modernization in Russia, China, India and other countries provides the plants reconstruction of wet production method and change into dry method; replacement of outdated kilns with new rotary kiln installation, decarbonizers and use of carrier-gas heat exchangers.

In 2011, cement production, where kilns equipped with external heat exchanger system were used, reached 1.8 billion tons, and the rate of this cement was 89%.

Only in 2012, 124 processing lines with a total capacity 160 million tons per year were commissioned in P.R. China, including:
3 lines with productivity 10 000 tons kL/day - 6.58%;
75 lines with productivity 4 000-8 000 tons kL/day - 70.47%;
45 lines with productivity 2 000-4 000 tons kL/day - 22.8%;
1 line with productivity 1 500 tons kL/day - 0.29%.

Effectiveness of cement production in China and India is improved by realization of the national complex programs. These programs include:
- development of energy-efficient technology at all stages of technological process;
- usage of alternative fuel and raw materials;
- usage of other productions wastes;
- increasing the rate of active mineral supplements in cement.

Implementation of these measures allows reducing specific energy consumption, CO2, NOX and SO2 emissions, to increase usage of production wastes.
The technology of the Portland cement modification into nano-cement developed by Russian scientists in recent decades allows to radically overview the development strategy of cement industry, gives the opportunity to reduce the unit costs of fuel and CO2, NOX and SO2 emissions per every ton of cement not by 8-10% as it is currently planned by the leading cement plants, but 1.5-3 times with the minimal investment, at the same time resolving the problems of energy saving, ecology and increasing amount of high-performance concrete.

According to our opinion, the new technology of finish operation of the Portland cement modification technology during the grinding processes of clinker is the most significant achievement in chemistry development and technology of Portland cement production in three centuries of developing of the main construction material of modern era.

The content of the new technology of Portland cement modification into nano-cement leads in formation of full nanosized in thickness covers - capsules from special modifier - over Portland cement grains during the process of mechanochemistry activation combined with Portland cement size reduction (1,2).

The basic technological scheme of obtaining the energy saving low-clinker nano-cements with mineral supplements is shown in Fig. 1.

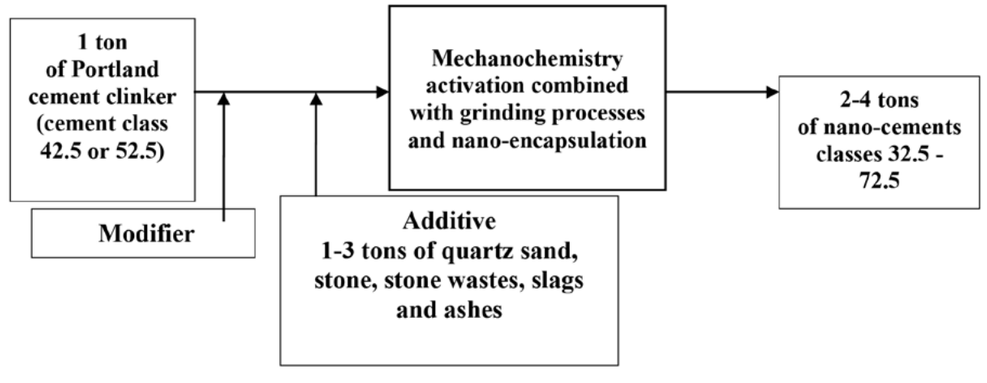

Fig. 1. Technological scheme of low-clinker nano-cements production

NANO-CEMENT TECHNICAL CONSTRUCTION PROPERTIES

Refinement of technical construction properties produced in the whole world of Portland cements shuddered to a halt for a long time and for several decades has not allowed increasing their activity, over classes 42.5 - 52.5 on durability. Currently, cements plants all over the world produce practically the same product, quality of which is detected by class or brand that include complex of requirements for technical construction properties. With this, the main characteristics are compressive and deflection strengths of stone samples during 28 days of hardening with varieties in rate of curing till this period.

The experience of more than 25 years of works on Portland cement technology modification into nano-cement, production of experimental-industrial and industrial lots of new material in the quantity several millions tons allowed to elaborate the nano-cements regulatory system for the first time in world practice.

In fig. 1 are shown the results of certification tests of nano-cements of various compositions, that were conducted in 2012 by SUE «NIIMOSstroy» with IIS «NANOCERTIFIKA», on the base of modified Portland cement PC-500 DO-N «Oskoltsement» CJSC and mentioned ordinary Portland cement in different variations of its content from 90 to 30% mas.

The results of certification tests of nano-cements of various compositions under the actual GOST demonstrated their full compliance with CJSC «IMET» TR - 5733-067-66331738-2012 «General-purpose nano-cement. Technical Conditions» elaborated by the affiliated company Moscow IMET Public Corporation. Nano-cements, saving the standard setting time, differ from basic Portland cement in greater specific surface, while fully maintaining the soundness and with significantly lower values of cement paste normal consistency (in average 17 - 20% instead of 26 - 27% of basic Portland cement). With such a low water requirement, cement and sand mixtures characterize by high workability (flow of all nano-cement compositions is 145 - 153 mm instead of 115 mm of original Portland cement - Table 1).

Taking into account the principal figures - hardening rate and compressive and deflection strength - all nano-cement compositions are better than ordinary Portland cement in all technical construction properties, allowing to improve cement class from 42.5 — 52.5 to 72.5 – 82.5.Under normal conditions nano-cement hardening rate is unprecedented for Portland cements. From there, the nano-cement 90 gives the opportunity to reach the record figures of cement stone in two days: compressive strength — 53.8 MPa, deflection strength - 7.1 MPa, nano-cement - 75 in 7 days of normal hardening allows to obtain compressive strength in stone - 68.5 MPa and deflection strength - 8.0 MPa.

Very important is the intensive strength generation of the cement stone on the base of low-clinker energy saving nano-cements at the beginning of the hardening process. Consequently, the nano-cement 55 with only 55% mass. of modified Portland cement demonstrated compressive strength in stone - 49.3 MPa and deflection strength - 6.3 MPa in two days of normal hardening, reaching compressive strength - 77.5 MPa, and deflection strength - 8.2 MPa in 28 days of hardening (Table 1).

The results analysis of industrial production of various cements (Table 1) shows that nano-encapsulation technology allows to reduce three times the amount of expensive cement clinker and obtain brand strength of cement stone (in 28 days of hardening), exceeded that one for cement without supplements.

In 2012, nano-cements of six types certification was made in IIS «NANOCERTIFIKA» at «RUSNANO» Ltd that verified full compliance of produced nano-cements TU – 5733-067-66331738-2012 «General-purpose nano-cement. Technical Conditions». At the end of 2014, the national prestandard 19-2014 «Nanomodified Portland Cement. Technical Conditions» was approved by the Russian Federation, and the international nano-cements patenting was begun.

For the first time in the world practice nano-cements were determined as nano-contained products of class B; the nanocover over cement grains was verified and Certificates of Conformance were obtained for nano-cements divided into classes according to quality: 82.5; 72.5; 62.5; 52.5; 42.5 and 32.5 - photo of Certificate of Conformance, for example, of the Nano-cement 90 class 82.5 in fig. 2.3. These Certificates (fig. 2.3 and 9.10) demonstrate safety data of production and nano-cement usage.

Firstly developed technology of low-clinker nano-cement gives the opportunity to reduce radically, 1.5-3 times, the unit costs of fuel and CO2, NOX and SO2 emissions per every ton of cement by reducing the content of clinker in such low-clinker nano-cements to 30% with saving of technical construction properties of Portland cement without any addition (Table 1).

Taking into account the principal figures - hardening rate, compressive and deflection strength - all nano-cement compositions are better than ordinary Portland cement in all properties, allowing to improve cement class from 42.5 — 52.5 to 72.5 – 82.5. Under normal conditions nano-cement hardening rate is a record. From there, the nano-cement 90 gives the opportunity to reach the record figures of cement stone in two days: compressive strength — 53.8 MPa, deflection strength — 7.1 MPa, nano-cement — 75 in 7 days of normal hardening allows to obtain compressive strength in stone - 68.5 MPa, and deflection strength — 8.0 MPa.

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Obtained nano-cements brand characteristics are the highest in three centuries of the cement industry. Reached rates are the best world achievement in cement technology in terms of energy saving, ecology, and quality.

Bickbau M.Ya.

THE NEW IDEAS OF PORTLAND CEMENT AND NANO-CEMENT MORPHOLOGY.

Tests conducted by our developed original method of the transmission electron microscopy showed that mineral grains of Portland cement clinker, unlike notions that had existed earlier, having the sizes from several to several tens mkm, are the complex polymineral conglomerates, formed from smaller, from several tens to 100 nm, particles mono- and polycrystals of two basic clinker minerals - tricalium silicate (alite) and dicalcium silicate (belite), connected with cleavage planes and encased with glass phase streaks of composition from 4CaO $Al_2O_3Fe_2O_3$ to 6 CaO 2 $Al_2O_3Fe_2O_3$, that crystallized partially depending on the speed of clinker forced cooling. There are also inclusions of a small amount of tricalcium aluminate in clinker grains of Portland cement.

First researches of real size of mineral crystals in the industrial clinkers proved that according to microstructure, the Portland cement clinker itself is a nano-product.

The formation of mono- and polycrystals of clinker minerals of small size (less than 100 nm) in the Portland cement clinker is due to the nonequilibrium conditions of clinker burning and the need of high heat density for crystallization of heat-proof (alite and belite melting temperature is more than 2 000 0C) minerals.

During the formation of the Portland cement clinker, even in the presence of the liquid clinker phase, alite and belite crystallize in baking zone at a temperature of 1 450-1 5000C. This process is periodical and quite brief (from several to several tens seconds) due to intensive moving of clinker nodules during the burning in rotary kilns, when the temperature gradient at the surface and inside the layer reaches hundreds of degrees. Specification of real morphology and identification of clinker minerals composition is complicated due to polymorphism of principal cement phases — alite and belite, the cumulative quantity of which is from 65 to 85% mass. in the clinker. Alites and belites crystallize in seven famous crystallographic modifications of atomic structures (3,4), transformation and preservation of which depend on the raw mix composition, impurity elements availability, sintering rate and clinker cooling.

Alite and belite in clinker are characterized by the block structure with demonstrated twin formation, twinning, flawed surface and phase activation. Typical Portland cement grains have a mosaic morphology (fig. 4). Porosity of clinker particles ranges from 7 to 10% mass.; its existence is recorded as highlights in dispersed clinker grains.

During the grinding processes, combined with Portland cement mechanochemical activation in the presence of modified polymer up to optimal dispersion level 400-600 square meters/kg, Portland cement transforms into the completely new product with highly outstanding technical construction properties. Earlier this material was named as low water demand binder (LWDB), low water demand cements (LWDCs) and dry mechano-activated mix (DMM) (1,2).

Long period, the phenomenon of radically growth of modified Portland cement technical construction properties could not be conceptualized and explained in view of institutional knowledge of cements physics and chemistry, until we have experimentally proved the Portland cement transformation during the process of mechanochemical activation in the presence of modifier into dispersive composite in form of Portland cement grains with structural modifier cover (5,6). We called such a dispersive composite as nano-cement, in consideration of nano-dimension of such covers over the cement grains.

Table 1

NANO-CEMENTS CHARACTERISTICS

tested on the base of TU 5733-067-66331738-2012 "General-purpose nano-cement. Technical Conditions" and the preliminary national standard 19-2014 "Nanomodified Portland Cement" by Testing Laboratory the State Unitary Enterprise "NIIMOSStroy", 2012.

Name of test	Ultimate working capacity of samples normal hardening, MPa						Nano-cover, thickness, *nm*	"Per unit" indicators** per cement ton, kg	
	2 days		7 days		28 days			fuel costs	CO_2 emission
	deflection strength	compressive strength	deflection strength	compressive strength	deflection strength	compressive strength			
original Portland cement cement PC-500 DO-N "Oskoltsement" lot #654	2.9	21.3	–	–	6.4	54.4	Absent	200	1070
NANO-CEMENT 90* C 82.5	7.1	53.8	8.0	72.6	8.7	82.7	30-120	180	960
NANO-CEMENT 75 C 72.5	6.9	54.7	8.0	68.5	8.5	77.8	30-115	150	802
NANO-CEMENT 55 C 62.5	6.3	49.3	7.5	65.4	8.2	77.5	15-100	110	588
NANO-CEMENT 45 C 52.5	4.8	39.9	6.7	57.4	7.9	68.1	18-95	90	481
NANO-CEMENT 35 C 42.5	3.9	30.7	5.8	46.6	7.2	61.4	15-100	70	374
NANO-CEMENT 30 C 32.5	3.0	20.4	5.6	46.4	7.6	52.1	14-85	60	321

- Figure hereinafter means the amount of Portland cement in nano-cement, the rest - finely ground quartz sand*

*-** Comparative figures are taken at the rate of the basic ones for Portland cement of the plant "Oskoltsement" that works in wet production method*

Thus, nano-cements are the cements characterized by all-over nano-capsule (cover) over the cement grains in thickness of several tens nm from modified polymer substance.

Great experimental research and test material, highlighted in various reports, allowed to prove the formation of nano-cover over its particles during the process of Portland cement mechanochemical activation combined with its grinding, due to the grafting and compositional change of modifier particles structure, in which the functional groups of polymer substance work with calcium and oxygenic specific centers on the surface of clinker particles, filling with calcium cations and forming the structural all-over nano-cover.

Modern research methods allowed to experimentally identifying the covers in nano-cements. Optimal nano-cement properties are reached during the nano-capsule formation in thickness of 30-60 nm proportionally over all clinker grains.

Nano-cement submicroscopic photos (fig. 5-7) demonstrate even fitting of cement grains with lighter nano-dimensional cover of structural polymer substance. The clearer edging-cover in thickness of 10-100 nm, fixed over cement grains with the electron microscope investigations, refers to the less density substance than clinker minerals and glass phase, density of which is approximately 3 g/cm3. Such substance is a structural polymer modifier, density of which is approximately 1 g/cm3.

Radically higher building-technical properties of nano-cements are explained by the formation of nano-covers over cement grains during the modification process via mechanochemistry processing, compared with famous and widely used Portland cements.

One of the significant properties of nano-cement, by contrast with ordinary ones, is the ability to conserve the quality, keeping it in containers or cement silos for years. This ability was proved by the results of industrial tests. According to actual standards of all countries, the storage period for Portland cement without noticeable drop in quality is no more than 2 months, whereas in contrast the storage period for nano-cement without quality loss is no more than 1 year, according to TU – 5733-067-66331738-2012 «General-purpose nano-cement» and the preliminary national standard of the Russian Federation 19 - 2014.

By now, considerable working experience has been gained from new Russian technology, primary normative framework has been developed, successful tests has been done, in particular, in the U.S., Brazil, Saudi Arabia and the UAE. The experience of industrial realization of mechanochemically activated cements - nano-cements - allowed beginning exploration of new technology in cement industry practice. 3 million tons of nano-cement have been currently produced and used in concrete production.

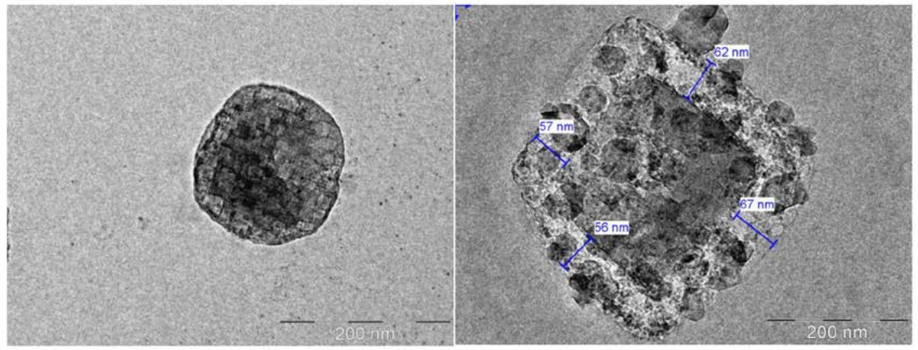

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Fig. 4. Typical electron micrographs transmission of Portland cement grain (a) and nano-cement (b). Blockiness, mosaic of the original Portland cement grain microstructure is clearly visible. Nanocover sizes are shown in the mosaic grain of Portland cement modernized into nano-cement (b). Scale in the photo.

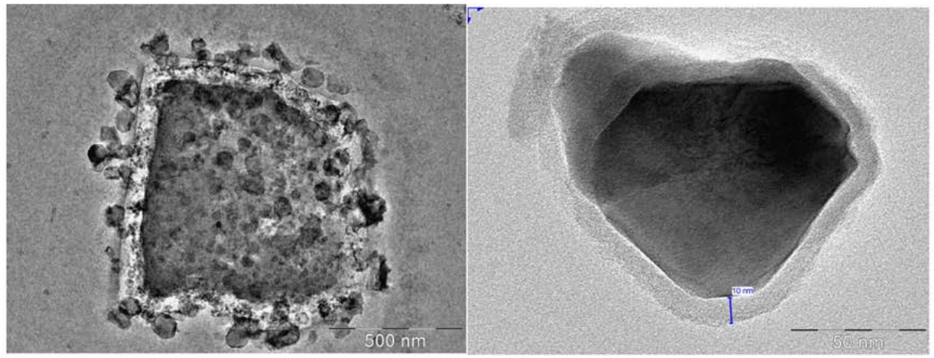


Fig 5. Submicroscopic photos of Portland cement grains with nano-covers. The photo to the right shows the nano-covers thickness. Scale in the photos. Samples of nano-cement 75 (to the left) and 90 (to the right).

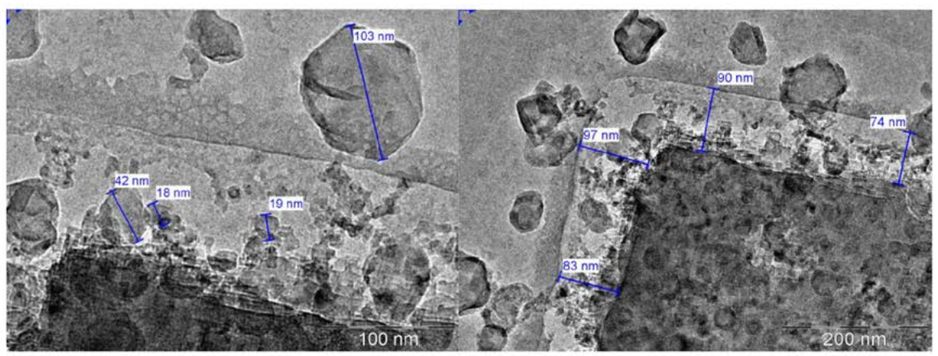


Fig. 6. Nano-covers over the Portland cement grains from the structural modifier in nano-cements. The thickness of covers is shown in nm. Submicroscopic photos. Scale in the photos. Small particles without nano-covers - quartz sand grains.
Separate microparticles that are visible through electron microscope approximately 100 nm in size (fig. 6) refer to the particles of quartz sand, over which the nano-cover from modified polymer is not fixed due to absence of zones with positive charge on the quartz grains surface.

CEMENT STONE. CONCRETES ON THE BASIS OF NANO-CEMENTS

Technical construction properties of nano-cements enable to produce from the high strength concretes B 40 class to the ultra-high strength concretes B 100 class and a wide range of ferroconcrete products without application of steam as well as fast hardening, waterproof and other types of concrete relevant for the modern construction. The production and application of the high-quality ferroconcrete products with extended durability and usage of substandard non-metallic aggregates has been mastered that is confirmed by the 20 years' experience of using new concretes in military, special, traditional construction and improvement activities (1,2,5-8).

Nano-cements enable to review the existing standards for producing high-quality concretes with 1.5-2 times lower Portland cement consumption. The attempts of producing high-quality concretes from the Portland cement and local usually substandard non-metallic raw materials require Portland cement overruns, and even when using expensive chemical additives don't assure the appropriate concrete quality in the construction of different buildings, roads, bridges, tunnels and overpasses.

Low-clinker nano-cements are the high-quality breakthrough in the concrete technologies. Using them enables to apply efficiently local small and large fillers that are substandard according to the existing standards, to accelerate concrete hardening, to denounce energy-intensive steams, to produce HPC class concretes and products on their base with reduced labor costs, to improve the technological level of all sectors concretes (both monolithic and precast) are used in, to simplify the production techniques applying the recent advances in off-shutter production.

Low-clinker nano-cements enable to produce high strength, waterproof concretes with long durability (6-8) on poor gravel and fine sands. Low-clinker nano-cements – nano-cements 30, 35, 45, 55 (Table 1) with high technical construction properties of the cements (fig. 9, 10) allow not only to reduce up to 3 times the unit costs per a ton of cement but also to decrease significantly their production cost (Table 3).

In the production of such concretes, the formation of the solid, waterproof and durable cement stone is carried out in own matrix composed of the high-basic hydrated calcium silicates and fine-dispersed siliceous phases with high surface mass transfer commensurate with the specific surface area of the nano-cement. So little influence of the small and big fillers' nature on the characteristics of the concretes in the low-clinker nano-cements can be explained only in this way, and it was experimentally proved of the non-metallic materials from different regions.

New approach significantly changes the binders' perception of the cements potential, increases the efficiency of their application in the nano-encapsulation by 200%-300% and enables to use fine-dispersed mineral additives as active reagent for the cement stone formation. Nano-cements enabled to improve and develop understanding of the cement morphology and properties as well as their hardening and hydration abilities and to explain the process of the hydro-silicate cement stone inside the concretes with original microstructure created through the molecular layer deposition at the atomic and molecular levels (9).

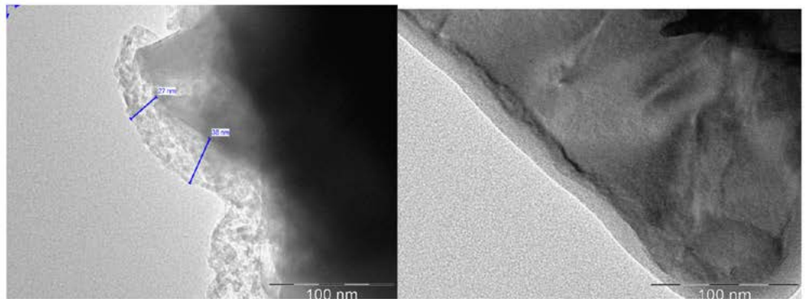


Fig. 7. Large Portland cement particles encapsulated with structural modifier nano-cover. Grain boundaries are shown. Scale in the photos. Nano-cement 90.

Concrete Test Results on the base of nano-cements NIIMOSstroy on request of the Federal State Unitary Enterprise (FSUE) "Administration of Civil Airports (Aerodromes)"

Table 2

No. Item No.	MTO per 1 $m_3$of RMC (cement-water factor = 0.275 CS = 3), kg	Concrete strength of normal hardening, MPa *in two months after nano-cement production is the numerator / figures of tested bagged nano-cements in one year of storage are in the denominator*								Characteristics of concrete		
		1 day		***3 days***		***7 days***		***28 days***		strength, kg/m^3	Freeze-thaw resistance, cyclic	Waterproofing qualities
		deflection strength	collapsing strength	deflection strength	collapsing strength	deflection strength	collapsing strength	deflection strength	collapsing strength			
1	*Nano-cement 40 M* – 370, including: Portland cement* – 148 silica additives (sand, slag, ash) - 222 + sand - 725 chip - 1225 water - 139	2.7	19.7 / 13.9	4.2	40.2 / 40.9	5.1	47.3 / 50.6	5.4	66.2 / 59.6	2455 / 2465	>300	W20
2	*Nano-cement 90 M* – 353, including: Portland cement - 301.5 silica additives (sand, slag, ash) - 34.5 + sand - 735 chip - 1240 water - 126	4.2	36.6 / 23.0	4.5	49.9 / 45.5	5.9	63.4 / 58.8	7.3	80.0 / 67.9	2475 / 2400	>300	W20

*** - Cement from Mordovskiy plant was used as original Portland cement to obtain nano-cement 40 M (40% mass. of cement) and nano-cement 90 M (90% mass. of cement): - 500 D O N, chip from Pavlovskiy quarry, M-1200 and building sand from Ramenskiy quarry, Mkr2.5, complying with GOST requirements concerning nonmetallic feed for concrete.**

The production of nano-cements and concretes on their base allows to advance radically the improvement and production opportunities of more high-quality cements and concretes, energy saving and disposal of different industrial waste, usage of substandard non-metallic materials, significant reduction of the CO2 emissions with increasing production volumes of the modern building materials.

The improvement of the ecological environment also depends on the efficient application of low-linker nano-cements of the industrial waste such as slag, ashes from different energy enterprises, metallurgy and other industrial branches the waste heaps of which take large lands around big cities. The cement clinker is replaced in the cement by significant amounts of slag, ashes and fine sands (Table 3) that solves ecological problem connected with the recycle of industrial waste such as slag, ashes and substandard natural small and large concrete aggregates. It is enough to point out that only in Russia the volumes of slag and ashes in waste heaps amounted to 80 billion tons and continued to grow as well as in other developing countries.

Therefore, the developed nano-cements technology allows solving comprehensively the energy saving problems in so energy-intensive branch as cement production as well as the problems of improving the qualities and the volumes of cement production – the main building material. It also allows improving ecological environment due to the efficient recycle of basic industrial waste heaps (slag and ashes) into low-clinker nano-cements.

The implementation of the low-clinker nano-cements technology gives a real opportunity to:
- reduce by 40-60 kg unit fuel costs per a ton of cement;
- radically improve the cement quality (1.5-2 times);
- to increase 1.5-1.7 times the production in the cement plant without constructing clinker burning steps by only developing milling sections;
- to decrease specific NOx, SO_2 and CO_2 emissions of the operating cement plants by 1.5-3 times per a ton of low-clinker cement;
- extend the terms of possible nano-cements storage from 2 months up to a year or more according to Russian and international standards;
- reduce the cement production cost price by 20-25%;
- reduce the cost of the nano-cement concretes by decreasing Portland cement consumption and applying local non-metallic materials that allow to save between 500 and 1000 rubles ($15-30) per a cubic meter of concrete mixture.

Mechanochemical cement activation combined with nano-encapsulation is a new direction of regulating technical construction properties of cement that is the most competitive with ordinary concrete mixtures modifying. This approach simplifies the requirements for large and small fillers, excludes microsilica and expensive chemical additives, allows to reduce significantly the cost of the cement, its consumption in the concrete and renounce its hear treatment.

More than 20 years of experience in developing and applying LWDB, LWDCs, DMM and PCTCZ– nano-cements predecessors – has showed in thousands of cubic meters of civil and special objects great superiority over Portland cements according to most indicators including hardening rates, grade hardness, waterproof, cold resistance and durability that allow to build both general and unique construction objects applying nano-cements (Table 10, 11).

New cements were produced under the state order in the Belgorod cement plant and cement slate combine of Zdolbunivsk as well as in more than a dozen of short technological lines. After the collapse of USSR, the LWDB production continued in the 81st ferroconcrete items plant in the city of Samara, construction materials plant in Moscow, Experimental cement plant at the Scientific Research Institute in the city of Podolsk and in the contractor #2 at the Ecotechprom in Moscow. In the recent years, the line with the capacity of 100 thousand per year has been mastered in the Sergievo-Posadsky concrete plant. Based on LWDB and its modifications harmonized in nano-cements, millions of cubic meters of different concretes were produced. In almost 30 recent years, these concretes have been successfully applied in the general and special construction. It is enough to point out the production of launch tubes for intercontinental ballistic missiles, subway tunnels, sleepers, aerodromes and road plates, breakwaters and berths, original buildings and constructions.

The widespread use of these cements in the Russian industry was impeded by the insufficient stability of the technical construction characteristics of certain producers and lack of the single normative base within the state.More than 3 million tons of nano-cements have been already produced with new technology, and the national planning project 19-2014 nano-modified Portland cement" has been approved.

According to the technical construction properties, the obtained characteristics of the nano-cement concretes show the possibility to improve radically the quality of concretes in Russia up to the level exceeding the world indicators. When talking about energy saving, an important prospect in the cement production and improving concrete technologies are the prospects of the low-clinker nano-cements that gives the opportunity for radical specific energy cost reduction up to 35-45% of masses per a ton of cement due to the decreased Portland cement clinker contents maintaining the technical construction properties of the materials.

Economy test for one ton of various classes nano-cements by reference to Portland cement cost and prime costs in the UAE

Table 3

Rough materials and materials	Unit cost, inc. VAT and transport, U.S./t $	Nano-cement 35 (Class 42.5)		High-strength Nano-cement 55 (Class 62.5)		High-strength Nano-cement 75 (Class 82.5)	
		Rate	U.S. $	Rate	U.S. $	Rate	U.S. $
Portland cement	70	0.30	21.0	0.45	31.5	0.75	52.5
Desert sand inc. transport	10 (40 kWhe)	0.65	6.5	0.55	5.5	0.25	2.5
Electricity costs	1.7	1	1.7	1	1.7	1	1.7
Labor costs	2.3	1	2.3	1	2.3	1	2.3
modifier	1000	0.01	10.0	0.011	11.0	0.012	12.0
TOTAL prime cost, RUB	–	–	41.5	–	**52.0**	–	**71.0**

Note: Cost accountings are for cement classes that are in most common use in building

So, the Table 2 shows the indicators of low-clinker nano-cement concrete where the correlation between clinker and powdered siliceous additives (sand, slag, ashes) as 40:60 that means the real Portland cement content amounts to only 148 kg, and the obtained concrete compressive strength already in 3 days of regular hardening reaches 40.2 MPa while it amounts to 66.2 MPa in 28 days having waterproof of 20 W and cold resistance of more than 300 cycles. At the consumption of the Portland cement concrete of 301.5 kg per a cubic meter, nano-cement 90 enables to get high strength method of B 60 grade with waterproof of 20 W and cold resistance exceeding 300 cycles.

According to the results of researches and tests, the indicators of the low-clinker nano-cements enable to produce strength fast hardening concretes with decreased Portland cement consumption even in substandard large and small fillers (Table 4)

Thus, the composition of the concrete mixture #1 (Table 4) includes ground in a form of large filler from the Southern portal of the ferroconcrete tunnel #3 fraction 5-20 mm with crushability grade 300, cold resistance F-25, plate and needle-shaped grains contents of 17%, sieve residue 5 – 83.2%, dust and clays particles contents of 3.5% that doesn't meet state standard (GOST) requirements 8267-93 and 26633-91.

Mineralogy coat research (composition 1, Table 4) via the method of X-ray structure phase analysis by measure demonstrated that as the main mineral phase (app. 80% mass.) it contains analzim - Na2OAI2O3 6SiO2 2 H2O, and also up to 10% mass. of calcite, up to 5% mass. of feldspathic rock and up to 5% mass. of kaolinite.

Introducing 335 kg of Portland cement with converted into nano-cement in a cubic meter of concrete mixture with so large substandard filler resulted enough to produce fast hardening B 55 class concrete (with hardening strength of 80% during the first 3 days) with waterproof W 16 and cold resistance exceeding 300 cycles (composition 1, Table 4).

Calcareous crushed stone (containing 96% of calcite according to RCA) with crushability grade 600 and cold resistance F 50 and plate and need particles contents of 5.1% (instead of 2% acceptable by GOST) of the fraction 5-20 mm of the ground from the Kamenskiy quarry of CJSC "Sochinerud" enabled to reach high strength in the first hardening terms with B 35 concrete class, waterproof W 20 and high cold resistance decreasing Portland cement consumption to 190 kg per a cubic meter of concrete mixture and apply ing it as nano-cement.

190 kg of Portland cement per a cubic meter of concrete mixture on the basis of nano-cement 40 enable to produce B 30 class concrete with waterproof W20 and cold resistance of at least 300 cycles (composition 3, Table 4). The record low Portland cement consumption in the concrete mixture based on nano-cement 30 (148 kg per a cubic meter of concrete mixture) enables to produce 600 grade concrete (B 50) – composition 1, Table 2. The mentioned concretes were applied in the construction of Olympic objects in Sochi.

The fact of drastic growth of the key quality indicator – nano-cements strength with mineral additives of almost any applied type (build sands, ashes, slag, tuff, mining and processing plants' tails and their different composition – is also very important phenomenon proved by our scientists and experience over many years.

The analysis of the results of the industrial cements production (Table 1) proves that the nano-capsulation technology allows to decrease the cement clinker contents in the concrete by three times getting cement stone grade strength at the level of pure clinker Portland cement without additives. At the same time, cement clinker in nano-cement can be replaced by significant (up to 70% of mass) volumes of slag, ashes and fine sands solving the important problem of industrial waste recycle in slag, ashes and non-metallic natural large and small fillers (figure 13).

Concrete standard test results on the base of low-clinker nano-cements in the State Unitary Enterprise "NIIMosstroy" on the base of off-quality fillers

Table 4

No. Item No.	MTO per 1 m³ of RMC, kg	CS	Concrete samples strength of normal hardening, in different terms, MPa in the numerator - compressive strength in the denominator - deflection strength			Characteristics of concrete		
			3 days	7 days	28 days	D, kg/m³	W	F
1	Nano-cement 90 - 395 including: Portland cement – 355 crushed sand - 40 + in the concrete mix: Ramenskiy sand (Moscow region), M_{kr}-2.63 - 920 ground coat South port. rwy tons -№3,M-300,F–25 - 921 water - 145 (input № lab. 97-1)*	3	57.6 4.3	64.2 4.6	72.4 7.0	2415	16	300
2	Nano-cement 75 - 410 including: Portland cement – 307 crashed sand - 103 + in the concrete mix: Romenskiy sand - 956 chip from mining Output «TO No.12 Bamtonnelstroy», M-1400 , F-300- 956 water - 123 (input № lab. 101-9)	8	67.1 5.0	67.1 7.2	73.4 7.5	2480	20	300
3	Nano-cement 50 - 380 including: Portland cement – 190 crashed sand - 190 + in the concrete mix: Romenskiy sand - 887 chip from Kamenskiy quarry, M-600 , F - 50 - 887 water - 165 (input № lab. 99-7)	7	35.6 3.7	43.0 4.1	43.5 4.6	2350	20	300

*- From now - denotation of concrete lots in experimental laboratory the State Unitary Enterprise "NIIMOSStroy",Moscow, Russia

First developed low-clinker nano-cements technology enables to reduce radically (1.5-3 times) specific consumption of fuel and CO2, NOx and SO2 emissions per a ton of cement due to decreasing Portland cement clinker contents in such low-clinker nano-cements to 30% of mass and maintaining high technical construction characteristics of Portland cement without any additives (Table 1).

In 2012, the certification of nano-cements was performed in ANO "NANOCERTIFIKA". For the first time, nano-cements were identified as nanocontaining B class product, the presence of nanoshell in the cement grains was confirmed, and the conformity certificates were obtained. Nano-cements were divided into classes according to the quality (82.5, 72.5, 62.5, 52.5, 42.5 and 32.5).

Build sand in simple concrete mixtures is characterized all over the world by quite large siliceous particles and siliceous minerals contents. The size of the majority of particles varies from 300 to 1000 mcm that makes the hydrosilicates forming reactions on the surface of the sand particles low-yielding. The sand particles surface doesn't exceed 50-70 square meters per kg during the interaction with much more fine cement particles with sized of 5-20 mcm in the presence of water (in the average specific cement surface of 300 square meters per kg in Russia and 4000 square meters per kg abroad). According to the valid world standards, fine sands are not suitable for producing concretes due to the increasing water consumption of concrete mixtures and reducing concrete strength.

The simplified version of chemical reaction that is necessary for producing cement stone in concretes. The version indicates initial and final composition of the reagents:

$3\,CaO\,SiO_2+3\,H_2O+SiO_2=2\,(CaO\,SiO_2\,H_2O)+Ca\,(OH)_2$

Under normal conditions the interaction of the components cement – water in modern concretes takes quite a long time and only in less-developed contact zones despite sand and cement ratio the particles usually correlate as 2:1, firstly, due to the small reaction surface of the chemically inert sand particles.It is commonly known, that the grade strength of the normal hardening concretes only about a third part of its utility is used. This is the most dispersed Portland cement part, and another two-thirds of the valuable energy-consuming product continue to hydrate in the concrete after 28 days of hardening without any utility, usually affect concretes' durability in the process of their exploitation.

In low-clinker nano-cement concretes the reactions between the cement and sand particles accelerate many times due to the fact that their sizes almost coincide with the sizes of actively absorbed emerging hydrosilicates and amount to several mcm (from 2 – 20) with average specific surface of solid particles that is about 500 square meters per a kg with decreased water contents in the system. Hardening Portland cement stone contains two types of hydrated minerals – calcium hydro silicates (85%) and calcium hydroxide (15%).

It seemed the calcium hydroxide contents isn't high but its presence reduces significantly technical construction properties of the cement stone, particularly its strength due to the plate layer morphology of the calcium hydroxide crystals between the layers of which the rift of the stone produces.

To improve the properties of the cement stone the calcium hydroxide contents should be avoided. However, option that is even more efficient is to integrate calcium hydroxide in the main concrete product – stronger and more durable calcium hydro silicate. It happens in the process of low-clinker nano-cements hardening following the reaction:

$Ca\,(OH)_2+SiO_2=CaO\,SiO_2\,H_2O$

This reaction is assured in the low-clinker nano-cements due to the similar silica or silica containing mineral additives (from 2 to several dozen mcm) dispersion level towards the size of the cement particles during the grinding.

The practice of many years of work with low-clinker nano-cements in concretes is compatible with it. Therefore, calcium hydroxide is almost impossible to identify. The calcium hydroxide contents in the concrete cement stone in normal Portland cement and low-clinker nano-cements needs different terms of hardening according to the X-ray quantitative analysis (% mass., Table 5).

Fig. 11.

All Saints Church build with nano-cement 90 in the thinwalled (40 mm) domes of this building in Dubna City, 2005.

Fig. 12

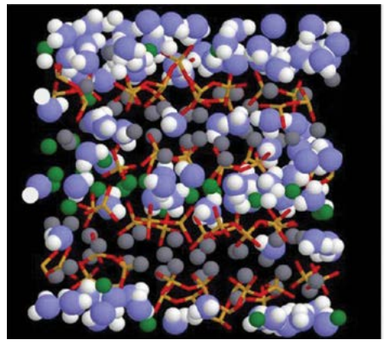
Waterproof case of the yacht made of nano-cement (wall thickness of the yacht boards is 12 mm) on Klyazma reservoir near Moscow, 2009

Fig. 13

а) б)

Photos of concrete chips in non-metallic large fillers, after 7 days of hardening after mechanical researches:
a) – with crushed stone from Kamenskiy quarry fr. 5-20, M600, F50 in the concrete with the obtained indicators – class B 30, W 20, cold resistance 300 cycles.
b) – with crushed stone of the ground from Southern portal of the tunnel #3 fr. 5-20, M300, F 25.
(Sochi, Krasnodar region) in the concrete with the obtained indicators - class B 55, W 16, cold resistance 300 cycles (after 28 days of hardening)

Fig. 14



Molecular model CSH (11). Blue and white colors show oxygen and hydrogen atoms in the molecule of water. Grey and green colors show calcium ions (intralayer and interlayer), yellow and red sticks – silicon and oxygen atoms in tetrahedrons).

Nano-cements (as well as their predecessors - LWDB, LWDCs, DMM) enable to produce high-strength and extra-strength concretes much easier and cheaper. Besides quite widely published results of the nano-cement (1, 2, 6 – 9) concrete tests, it's necessary to point out the intensive concrete strength growth even with record low Portland cement contents in the concrete mixture and significant increase of the basic concretes' characteristics – strength, waterproof, cold resistance, possibility to renounce high energy steaming of products and usage of substandard raw materials.

Strength and other properties of nano-cements concretes are determined by not so many characteristics of fillers grains, but cement stone in the nano-cement concretes. When its mechanical destruction happens, the rift produces in the grains of large filler – crushed stone that proves that nano-cement stone has even higher strength than granites.

In the researches (1,3,4) using X-ray structural analysis of the best ever obtained monocrystals of known alite and belite modifications it was proved that alite (C_3S) and belite (β-C_2S),contain in crystal lattices clusters of silica tetrahedron triads $[SiO_4]^4$ surrounded by repeating strips of calcium and oxygen — Ca — O — Si — O — Si — O — Si — O — Ca — and with some calcium atoms with higher (higher than usual one including 6 units) oxygen coordination.

Higher calcium atoms coordination in high-basic cement silicates assures higher ions level and its connection with oxygen atoms determining the minerals ability to interact with water when hydrating (10). Developing these ideas allowed the author to suggest that such clusters can convert with minimal changes from waterless phases into hydro silicate formations structured by active water molecules that are absorbed by the cement grains and produce structurally similar hydro silicate clusters of calcium.

These suggestions are in line with the recent advances of the group of physicists (USA, France and other (11) who have elaborated so-called realistic molecular model of cement stone – new model of nano cluster hydro silicates of calcium CSH.

This cluster is based on the silica oxygen incomplete frame. The layers of the calcium atoms are aligned to it through the oxygen bridges with sparser interlayer calcium cations.

Water is represented in calcium hydro silicates in molecular form as layers along calcium polyhedras of the described clusters and in its voids (figure 14). In the two-dimensional space, one basic element of the hydrated cement contains some deviations characteristic for the natural calcium hydro silicate – tobermorite. In new CSH structure, in triangle layers (siliceous tetrahedrons) every 3rd, 6th and 9th of them are rotated up or down of the horizontal axis (towards the nearest calcium oxide layers). In the formed "cavities" (layers formed by the calcium oxide strips), there are water molecules that coordinate active centers on the surface of the strips that form hydrated hydro silicate clusters of calcium from the non-hydrated high-basic silicates clusters. These hydrated clusters provide hardening cement stone with the strength and other characteristics.

Therefore, calcium hydro silicates aren´t pure crystals but represent a kind of hybrid from crystalline and amorphous components. They correspond all features of metamict structures according to (12).

Therefore, calcium hydro silicates aren´t pure crystals but represent a kind of hybrid from crystalline and amorphous components. They correspond all features of metamict structures according to (12).

The above described model was created through the computer stereo adjustment of the location of molecular groups $[SiO_4]^{4-}$, CaO, H_2O, OH to the CSH phase indicators: C/S 1,6; density (γ) 2,6 grams/cm3 - quite close to the real values. When elaborating this model structure, the creators were not oriented by well-known hydro silicate minerals. Despite estimated spectrograms resulted close to the layer tobermite and jennite data, the atom structure of the model fundamentally differs from the structure of the mentioned natural minerals.

Table 5

Free calcium hydroxide contents in the concrete stone in different hardening terms under normal conditions

	3 days	7 days	14 days	28 days	60 days
Portland cement	3,2	5,5	6,4	7,1	8,2
Nano-cement – 75	1,5	2,5	3,0	2,7	2,4
Nano-cement – 50	0,8	1,1	1,6	1,5	1,3
Nano-cement – 40	0,5	0,9	1,4	1,2	1,0

The similarity of the structures of the above described clusters in non-hydrated high-basic calcium silicates and calcium hydro silicates in the concrete can be explained by the understanding of the earlier unknown idea concerning intensive and fast cement sand slurries settlement and cement stone hardening that actively accelerates when adding water to the low-clinker nano-cements with finely powdered siliceous additives being part of the calcium hydro silicates formation reactions. When producing low-clinker nano-cements concretes, the formation of strong, waterproof and durable cement stone occurs in own matrix composed of hydrated high-basic calcium silicates and high-dispersed siliceous phases with developed mass transfer surface that is commensurate with nano-cements surface.

Only this mechanism can explain little natural influence of large and small fillers on the characteristics of the low-clinker nano-cements concretes. This fact was revealed to us and confirmed experimentally on the non-metallic materials from different regions.

Electronic microscopic researches carried out by us have detected quite distinctive structure and morphology of the cement stone in the nano-cements concretes compared to other described Portland stone structures. By means of scanning zone microscopy (SZM NtegraPrima) were registered three-dimensional chips areas from the surface of nano-cement concretes after one year of hardening under normal conditions.

The obtained images of the studied samples of nano-cement concretes show that the relief of the cement stone chips with amorphous slayer hummocky structure almost don't have characteristics of crystalline formations like calcium hydro oxide that are usually observed during hardening of concretes on traditional Portland cements.

The relief height reaches 120 nm, on the obtained photos we can clearly observe layer structure of cement stone along the spatial axis (Figure 15). According to our estimations, layer thickness in the cement stone is about 10nm.

So radical morphology differences of cement stone in nano-cement concretes with fine silica and consequent extraordinary high rates of technical construction properties of these concretes can be interconnected with topochemical hydration mechanism of high-basic calcium silicates with calcium atoms in higher (higher than 6 units) oxygen atoms coordination that produces in crystal lattices minerals, cavities, hydrogen water ions available for diffusion and grip on uncompensated oxygen atoms of active clinker particles surface with intensive formation of structural hydro silicate calcium fragments (1,10).

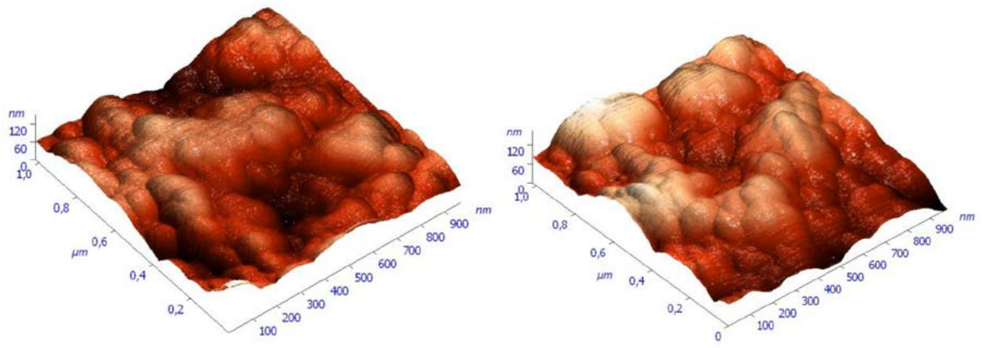
The development of these ideas allows to suggest that the above described clusters from silica triadscoordinated by calcium oxygen complexes with minimal changes move from non-hydrated phasestohydro silicate formations structured with active water molecules absorbed by cement grainsand generating hydro silicates clusters with similar structure according to the molecular slayer mechanism of Aleskovskiy V. B. (13).

This process is particularly active when present dispersed particles of siliceous fillers and relative minerals that already at the first terms start delivering silica for structural reconstruction of non-hydrated high-basic silicates into calcium hydro silicates. This approach explains the above-described slayer morphology of cement stone formations (characteristic for low-basic calcium hydro silicates) in low-clinker nano-cement concretes.

There can't be any doubt that nano-cements will start new era in developing world cement industry and improving concretes technology, providing significant energy saving, decreasing fuel consumption and CO2,NOx and SO 2 emissions, increasing concretes quality with decreased cement consumption, reduced production cost of the principal construction materials of modernity.

The most optimal lines for plants producing precast ferroconcrete are lines with productivity from 3-4 to 5-6 tons of new cements per hour. In this case, the volumes of nano-cements enable to provide all production volume of ferroconcrete of the enterprise. The average project capacity of the FCP plants is 120 thousand cubic meters of concrete products per year. When building lines with capacity of 20-25 thousand tons of nano-cement in the FCP plants taking into account the usage of existing infrastructure the required investments can be reduced to $15-20 per a ton of product.

Figure 15



SZM – three-dimensional images of the chip surface of cement stone in the nano-cement concrete of 1 year hardening. Dimensions on the axis.

LONG TIME PERFORMANCE OF CONCRETE ON THE BASE OF NANO-CEMENTS

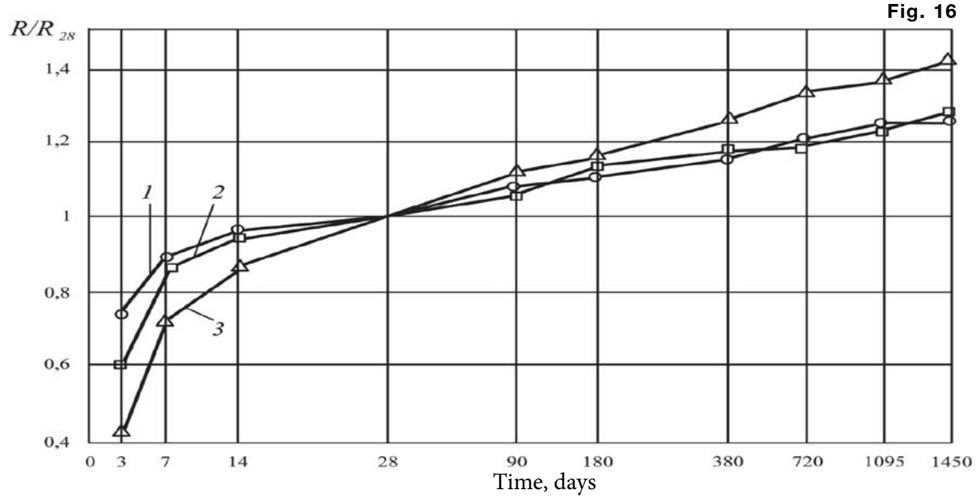
Fig. 16 shows the results of long researches (up to four years), in which they estimated the concrete hardening rate in normal conditions of experimental-industrial batches (original material — Portland cement from Starooskolskiy cement plant, mineral substance - mix of quartz sand and furnace cinder in the 1:1 ratio). With permanent consumption of binder 300 kg/m^3 and fluidity of concrete 1-4 cm, concrete strength on the base of clean clinker nano-cement LWDB-100 at the age of 28 days was 70 MPa, nano-cement 50 - 60 MPa, nano-cement 30 - 38 MPa.

At the early age (3-7 days) concrete hardening rates on the base of nano-cements 50 and up to clean clinker nano-cement (LWDB-100) are significantly higher than the concrete on the base of nano-cement 30. Thus, at the age of 3 days the relative values of the concrete strength on the base of nano-cement 50 and clean clinker nano-cement (LWDB-100) are 60 and 73% consequently, but on the base of nano-cement 30 - only 42% (fig. 16).

Continuing to harden, rates of concrete strength growth on the base of nano-cement 50 and clean clinker nano-cement (LWDB-100) become almost equal and strength gain at the age of one year and four years is 15-17 and 25-27%, respectively (fig. 16). By contrast, concrete on the base of nano-cement 30 has more significant strength gain, that is 26 and 42% at the same period, due to lasting pozzolanic reaction, whose holding in strength formation increases during the long hardening.

At the average, rates of concrete strength growth on the base of nano-cements with clinker part 50% and more correspond to rates of high-strength Portland cement concrete strength growth during the long hardening. But using nano-cement 30 - correspond to rates of low- and middle-strength concrete strength growth on the base of pozzolanic cements and Portland cements with mineral substances. In each case, it is noticed the long and stable strength gain of concrete on the base of nano-cements, and some strength rates deviations are within the dispersion of experimental data.

Fig. 16



. Rates of concrete strength growth on the base of nano-cements, depending on nano-cement class: 1 - clean clinker nano-cement (LWDB-100); 2 - nano-cement 50; 3 - nano-cement 30 (nano-cement classes, respectively, 82.5; 62.5 and 32.5)

APPLICATION AREAS OF NANO-CEMENTS

On the base of nano-cements it is useful to produce:

- High quality and durable concrete for the antiseismic construction, erection of high-rise buildings from Tube Confined Concrete and solid mass.

- Ultrastrong concrete for special constructions, engineering constructions and architectural complexes (thin covers, supporting columns, tubings, cross-beams, concrete skeletons and bridge conduits).

- High quality concrete for road constructions (paving slabs for pitched works of roads, grounds, platforms, take-off strips, aerodromes, solid-cast yard paving of petrol stations and overhead roads, crash barriers, border ledges, bollards and others).

- Concrete for hydro technical constructions, including marine structures for drilling installation of crude oil output .

- Architectural concrete (molten artificial stone) and products on its base for the provision of urban amenities: fountains, planters, bas-reliefs, sculptures and others).

- Products from architectural concrete of Moscow Institute of Material Sciences and Enabling Technology, Public Corporation adopted at the Moscow enterprise of construction materials as per technology of the Institute from 1997, included in the Moscow territorial construction catalog, p. I «Small architectural forms and elements of landscape design», Moscow, 1999

- High-quality economic dry building mixes of various profiles (for stucco works, masonry, for poured floors, brick and others).

- Concrete and antifreeze mortars.

- Light no-fine concrete as per technology «KAPSIMET» with cement content concrete within 100–140 kg per 1m3 of product and monolithic wall.

HIGH QUALITY CONCRETE

High quality concrete on the base of nano-cements possesses such advantages as (Table 6):

- high fast strength (from 40 to 70 MPa during the first day of hardening);

- good workability and cone slump up to 10 cm with cement-water factor no more than 0.25;

- possibility to be used in concrete production of off-quality fillers (fine sand, river gravel, stones from poor rocks).

Characteristics of high quality concrete on the base of nano-cements

Table 6

Item No.	Rate name	Values for different high quality concrete rate class (grade)		
			B 65 M 900	B 75 M 1000
1	Compressive strength in 1 day of normal hardening (stripping strength), MPa, no less than	42.0	56.0	70.0
2	Compressive strength in 28 days of normal hardening (stripping strength), MPa,	80.4	91.7	93.2
3	water absorption capacity, %, no more than	2.5	2.0	1.5
4	Cold-resisting quality grade, no less than	F 700	F 800	F 800
5	abrasion capacity, g/cm^3 no more than	0.4	0.4	0.4
6	Waterproof, no less than	W 12	W 14	W 16

ULTRASTRONG CONCRETE

Ultrastrong concrete on the base of nano-cements, stones and quartz sand significantly differs from ordinary concrete in their properties and possess:

- no-shrink condition;
- ultraimpermeability;
- high durability;
- high fast strength;
- high workability during vibrational impacts;
- regulated periods of hardening;
- long term durability;
- natural stone polish capacity;

High quality and ultrastrong concrete on the base of nano-cement - perfect construction materials and products with high reliability and durability. Common advantage of all reinforced concrete constructions with high quality and ultrastrong concrete on the base of nano-cements, besides technical construction properties, is lower cement factor, in comparison with the traditional one, usage of more available nonmetallic concrete fillers and constructions cost reduction, provision of maximal stability and durability.

Significant properties of concrete on the base of nano-cements allow:

- to make products from architectural concrete with rates close to the natural granite, but in 3-5 times lower priced; with the possibility to grind and polish them, as natural stone;

- to produce high, and ultra-high strength concrete (up to the B60 class) with high-level waterproof (W16-W20), high resistance to sulfates, chlorides, and weak acids;

- to assure metal (fittings) economy 30-50% in high, and ultra-high strength concrete;

- to speed up product hardening that in one day reaches the strength 60-70 MPa, and at the age of three days reaches the strength (no less than 70% of grade concrete strength at the age of 28 days of normal hardening);

- to reduce 1.5-3 times cement content of fresh concrete due to nano-cements and mechanic activation of siliceous aggregates (fine-grained sand, rocks, ashes, slags);

- to make possible the processing of Portland cement as well as clinker, the realization of technology autonomously or via integration into the current technological process of cement production;

- to reduce energy requirement of concrete production via the exception of steam during the product hardening;

- to produce architectural concrete with extra decorativeness (clear tone, rich color) resistant to lime scale (efflorescences) during the exploitation in contaminated conditions of megalopolises;

Fields of application and utilization efficiency of nano-cements in various constructions:

Multistory buildings and constructions
Reduction of Portland cement factor:
in supporting columns – 2-3 times;
in slabs – 1.3-1.5 times.

Speeding of timbering rotation – from 2 to 3 times
Total cost reduction of building skeleton – from 20 to 40%.

Hydro technical and underwater structures
Increasing of durability – from 2 to 3 times
Reduction of Portland cement factor – up to 2 times;
Cost reduction of construction – from 30 to 50%.

Tunnels. Mines
Reduction of Portland cement factor – 1.5 times;
Increasing of durability due to concrete waterproof – 2 times;
Cost reduction – by 20–30%.

Bridges, roads, overhead roads
Reduction of Portland cement factor – 1.5 times;
Increasing of durability – up to 2 times;
Cost cutting – from 15 to 25%.

Defensive constructions
Increasing of construction integrity – from 2 to 2.5 times;
Increasing of stability and durability – from 3 to 5 times.

Characteristics of ultrastrong concrete on the base of nano-cements

Table 7

Mechanical characteristics		**Physical properties**	
Compressive strength	100-150 MPa	Volume weight	2600–2700 kg/m^3
Ultimate working capacity during deflection strength	10 - 15 MPa	Durability	unl
Strength during scaling	8-12 MPa	Waterproof	up to 20 W
Elastic modulus E*103	45-60 MPa	Cold-resisting quality	800 F
Limited range of formability* 10-3	2.6-3.0	Shrinkage cracking	absent
Dynamic amplification ratio	1.4-1.6	Build-up of strength in time:	
Poisson's ratio	0.20 - 0.22	1 year 5 years 10 years, etc.	15–20% 20-25% up to 30%

DRY MORTARS ON THE BASE OF NANO-CEMENTS

Moscow IMET Public Corporation also developed different compositions of dry building, repair and special mortars for utilization in various building spheres.

Dry repair building mortars on the base of nano-cements

Designation

They are designed to fast and quality repair of concrete, fibercrete and reinforced concrete pavements for street railways, automobile roads and landing strips, structural members of bridges, tunnels, buildings and constructions, underwater works.

Technical characteristics

Ready to be used, high quality, quick-hardening dry repair building mortars that consist of nano-cements, fractionated filler, reinforcement fiber of special additives. Depending on the rate of strength gain, they are classified as quick-hardening and ultra-quick-hardening dry mechano-activated mortars on the base of nano-cements (Table 8, 9).

Recommendations for use

Repair of horizontal surfaces is made via the grouting against formworks. For the repair of vertical walls and inclined surfaces, special thixotropic compositions (with high workability during a mixing operation and HV at rest) are used.

Approximately 2.0 tons of dry mortars are needed to obtain 1 m^3 of concrete.

Dry repair building mortars on the base of nano-cements for concrete surfacing:

- Underground and multi-stored car parks, service stations. Shops and malls.
- Warehouses with intense mechanical loadings.
- Production areas, including paper mills, meat processing factories.

Recommendations for use

Concrete flooring with high-impact top layer includes following operations:

- reinforcement across the surface;
- placing concrete and leveling;
- vibration of concrete;
- hardening of the top layer via mechanical wiping with composition wheel of trowel in crude concrete;%
- polish grind of surfaces
- 3.5-5 kg of dry repair building mortar on the base of nano-cements are needed per 1 m2 of the square with layer thickness 3-5 mm.

Technology advantages:

- compressive strength hardening of floor covering by 35% and more;
- reduction of durability and dust-precipitating plant 3-4 times;
- high impact property and oil holding property;
- capacity for surface polishing;
- easy and qualitative accommodation cleaning;
- production of surface with colored ornament
- architectural expression and durability.

Characteristics of dry repair building mortars on the base of nano-cements

Table 8

Technical characteristics	Mortar type	
	quick-hardening	ultra-quick-hardening
Compressive strength, MPa, at the age of:		
3 hours	–	30
1 day	30	40
28 days	60-80	50-30
Adhesional strength with concrete, MPa, at the age of:		
3 hours	–	1.5
1 day	1.5	1.8
28 days	6.5	4.0
Consistence saving, no less than	1 hour	12 min.
Cold-resisting quality, cycles, no	300	
Water-proof, no less than	W 14	

Note: Depending on aggregate fineness, thickness of the repair layer is from 15 to 100 mm

Principal properties of dry repair building mortars on the base of nano-cements for colored decorative coats

Table 9

Technical characteristic	Indicator values
Compressive strength, MPa, (28 days)	80-85
Transverse strength, MPa, (28 days)	10-12
Abrasion capacity, g/cm^2	0.4-0.7
Chemical stability	Resistant to water, petrol, oils, emulsions, washing agents
Cold-resisting quality, no less than	F 300
Water-proof, no less than	W 12
Color	Red, gray, green, yellow, blue, black

Note: thickness of top hardened layer is 3-5 mm

PRONIX — INNOVATIVE WATERPROOF AND REPAIR MATERIALS ON THE BASE OF NANO-CEMENTS

Problems that concern waterproofing, repair and recovery of reinforced concrete structures, including higher complexity objects, can be effectively resolved, using modern materials and technologies. Today, one of such advanced materials is The waterproof dry building mixes PRONIX, produced on the base of general-purpose nano-cement, elaborated by the Moscow IMET Public Corporation and certified by the branch of RUSNANO - NANOCERTIFICA LLC (16, 17).

Utilization of nano-cement in the mixes PRONIX, with complex of various modificative additives, gives to PRONIX products high waterproof, strength and injection properties. Utilization of nano-cements in the mixes PRONIX allows increasing the penetration into concrete as a part of penetrating waterproofing salts, contributing free calcium and intensifying crystal growth in the concrete pores and microcracks, giving it the hydro technical and waterproof properties. Materials adhesion also improves. Building mixes PRONIX are easy in use; don't need special skills and high qualification of workers. Alternatively, to the utilization of rolled materials, there is not demand for fire hazardous works. If necessary, the reconstruction of structure strength properties and moisture-proofing of subsurface parts of buildings and constructions is enough to make inside premises, basements.

PRONIX materials on the base of nano-cements 30 - 75 are used for repair works in the most complex situations, when serious problems with waterproof appear. It's not necessary to dry the surface with "PRONIX" materials, moreover, it's better to apply them on humid surface. Service life of our materials is equal to the concrete working life and corresponds to 50 years. "PRONIX" materials provide the recovery of the construction integrity due to the deep penetration of the smallest components in the construction, stopping water filtration and increasing strength.

All range of "PRONIX" products is certified to GOST system, fireproof. The Federal Service on Surveillance for Consumer rights protection and human well-being permits the utilization of these products in storage tanks with drink water. It means the highest quality and ecological safety of "PRONIX" materials. By the way, company products are on par with foreign analogs in terms of quality, but in some cases they are even better, taking into account much less cost. Currently, "PRONIX" produces 18 types of product.

There are the materials of penetrate type, repair for joints, seams, cracks, hydraulic seals, waterproof maintenance coatings, modifiers, mineral, grouting, epoxy, safety-decorative, elastic and other compositions, including purpose-made. It should be highlighted the ultra-penetrating materials as well as grouting material - Nanoinject that contains mineral components - nano-cement, bentonite clay, dolomitic meal and others, whose grading fractions do not exceed 25 microns. And, of course, complex modified additives into concrete of both chemically oriented and on the base of microsilicasuspensions that modify concrete to the hydro technical state. More information about PRONIX materials you can find on the website www.pronicks.ru

PRONIX company provides waterproof and repair works in different spheres of the building industry. Works are executed both on the private facilities and on large industrial ones of national importance.

PRONIX materials were effectively used on the important objects:

- Building No.1 (Residence of Presidents of the Russian Federation), Building No.14 - the Kremlin
- Waterproof of concrete beds and bases during the construction of 17-storied buildings in Protvino City (Moscow region);
- Repair and recovery of waterproof inside the basement of five-entrances residential house in Bolshevik village (Moscow region);
- General waterproofing as well as waterproof of communication inputs, including injection activity during the construction of two storage tanks in a volume 1000 m3 in the Serpukhovskiy district (Moscow region);
- Bank protection of the palace pond of the grange Kuskovo, Moscow;
- BOSes, Zheleznodorozhnyi City (Moscow region);
- Moskvodokanal;
- Cable, catch basins, including in Moscow;
- Rokskiy vehicular tunnel in Ossetia;
- The palace pond of the grange Kuskovo — bank protection and also such objects as RosAtom, Nornickel, RR, Polymetal, Industrial Investment Corporation, CC BRIDGE.

Read more about the materials PRONIKS can be found on the website www.pronicks.ru.

PERSPECTIVE EVALUATION OF PRACTICAL NANO-CEMENTS UTILIZATION

Taking into account that cement industry in P.R.China is the largest in the world and China is the producer of 70% of cement facilities, development of nano-cement technology will allow to change the total development strategy of cement industry, increase 1.5-2.0 times the volumes of world cement production without building of new cement plants and raw material quarries, only due to increase in capacity of the grinding departments. It is possible to upgrade the cement plants of Russia, P.R. China, the UAE, India, Brazil and other countries via the extensive realization of energy saving nano-cement technology with utilization of Chinese facilities on the base of common cooperation (fig. 16).

Currently, the effectiveness of cement production in P.R. China, India, and other countries is improved by realization of the national complex programs.

Approved National Programs include:

- development of energy-efficient technology at all stages of technological process;
- usage of alternative fuel and raw materials;
- usage of other productions wastes;
- increasing the rate of active mineral supplements in cement.

The experience of industrial realization of mechanochemically activated Portland cements — nano-cements — allowed beginning exploration of new technology in cement industry practice. 3 million tons of nano-cement have been currently produced and used in concrete production.

Nano-cements allow to overview the existence standards all over the world not only in cement sphere, but also in various concrete productions. Thus, particularly, nano-cement usage allows withdrawing from steam of products and constructions from reinforced concrete and concrete, radically simplifying requirements for nonmetallic feed used for rocks and quartz sand.

Utilization of these measures in the nano-cements and concrete technologies gives the opportunity to reduce unit costs of energy, the CO_2, NO_X and SO_2 emissions, to use nonconforming, to date, according to the existing rules, nonmetallic feed (weak rocks, desert sands) and different industrial wastes. Nano-cement technology allows resolving effectively all issues of refinement of the cement industry and concrete technology in P.R. China, India, BRICS and SCO countries and other regions all over the world.

The possibility of nano-cement technology utilization in the UAE, P.R. China, Brazil and other countries can be realized in two forms:

1. Improvement of the traditional cements classes to classes 72.5 - 82.5 that are produced nowhere, except Russia. These cements are notable for the intensity of strength generation, and possibility to produce concrete on their base without thermo-moist curing with high and ultrahigh strength characteristics during the concrete hardening. In this variant, the technology can be realized at the cement plants more or less without investments, in 2-3 months according to the prepared regulatory and technical documentation.

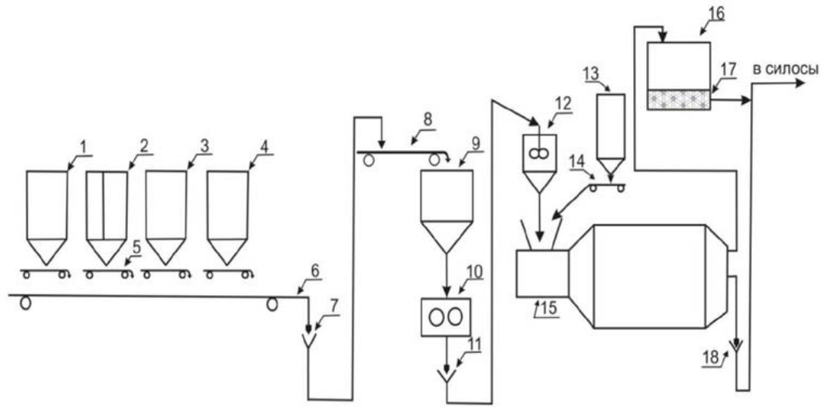
2. Productions f low-clinker cements with mineral additives (up to 70% mass.) with expansion 1.5-3 times in the production capacities of the cement plant due to increase in capacity of the grinding departments. In this case clinker of cement plants under the offered technology will processed into the nano-cements of 32.5-72.5 classes with addition per each clinker ton from 1 to 3 tons of mineral additives in form of nonconforming natural sands, aluminosilicate rock formations, and also slags, ashes and other wastes.

In both variants, cost of needs includes cost of the international manufacturing license for nano-cements that amounted to $1-2. per 1 cement ton depending on the power of the factory. The conditions of the licensing agreement and royalty can be agreed during the communications with each concrete plant or firm.

Cement plant, that realizes the technology of low-clinker nano-cements without increase in capacity of the grinding department, can produce such cements in volume of their powers with simultaneous distribution of 40-60% of its clinker at the marker.

On plant request — the buyer of new technology - to increase its production volumes, than, in this case, necessary investments will include costs for purchasing and installation of additional milling equipment of cement plant or large concrete manufacturers. Moscow IMET, Russia, DANIRA, the UAE and their affiliated firms, together with machine-building plants of P.R. China, the Russian Federation and other countries, can do the complex of engineering services, including delivery of equipment and help in nano-cement technology development.

The wide prospect of the nano-cement technology is dictated by the key issues of the cement manufacturing of Russia, the UAE, P.R. China, India, Brazil and other countries - the need for significant increase in cement production, reduction doubled or tripled unit costs of fuel, CO_2, NO_X and SO_2 emissions, quality improvement and reduce costs of cement and concrete, utilization of collected values of industrial wastes, use of nonconforming nonmetallic feed and improvement of the planet ecology.



1. Coal slag storage hopper 2. Bunker bench of plaster and igneous rock stone 3. Bin for slate 4. Bin for clinker 5. Weight batchers (strain-measuring) 6,8. Band type conveyors 7,11,18. Chain elevators 9. Bin feeder 10. Press-rolling rock pulverizer 12. Bin feeder with impeller for mix homogenizing 13. Modifier bin feeder 14. Proportioning belt 15. Ball mill 16. Fabric filter 17. Screw

Fig. 16. Processing line for the production of low-clinker nano-cement on the base of cement clinker processing with a capacity of 50 t per hour, Shin-Hua plant, P.R. China

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CEMENT AND CONCRETE REVOLUTION. THE PRELIMINARY STANDARD — NANOMODIFIED PORTLAND CEMENT IS APPROVED IN RUSSIA

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One of the first preliminary national standards for the innovative construction materials became the preliminary national standard PNS 19-2014 "Nanomodified Portland Cement. Technical Conditions", approved by the Federal Agency on Technical Regulating and Metrology of the Russian Federation in December 2014. It allows the Russian enterprises to use the basic construction material with significantly higher building-technical properties than traditional portland cement.

The nano-cements became accessible to building investors and design institutes, technological organizations and cement plants, producers of dry mix, various concrete and mortar production not only in Russia, CIS states and the Eurasian Economic Union, but also in other countries due to international patenting of nano-cement and its production method.

The new material successfully underwent all stages of testing and for the first time in world practice obtained certification as the nano-product on the base of integrating tests "NANOCERTIFICA" LLC at the RUSNANO Corporation with the State Unitary Enterprise "NII-MOSStroy", MC "RUSNANO" and other organizations.

The preliminary national standard was developed due to the wide commercial introduction of new types of the portland cement - the general-purpose nano-cement, made on the base of the nanomodified portland cement that has undergone successful industrial tests, and also has obtained the experience in concretes manufacture and different building spheres.

The prestandard uses the research and technology solution that allows to radically improving the building-technical properties of the general-purpose nano-cement, including:

- to provide cement strength upgrading up to classes 72.5 – 82.5;
- to reduce expensive clinker part up to 30% mass in low-clinker nano-cement composition through the substitution of its clinker part with less expensive mineral supplements up to 70% mass. (slags, boiler fly ashes, fine-grained sands, rocks) with saving of high building-technical cement properties;
- to reduce doubled or tripled unit costs of fuel and the CO_2, NO_X and SO_2 emissions per every ton of cement;
- to improve the quality and increase the useful life of concretes on nano-cements base.

The developed technology of the portland cement modification can be realized on existing equipment and at any cement plant or enterprises on manufacture of concrete, concrete and reinforced concrete products and constructions, and also in the major building works (scheme - in fig.1).

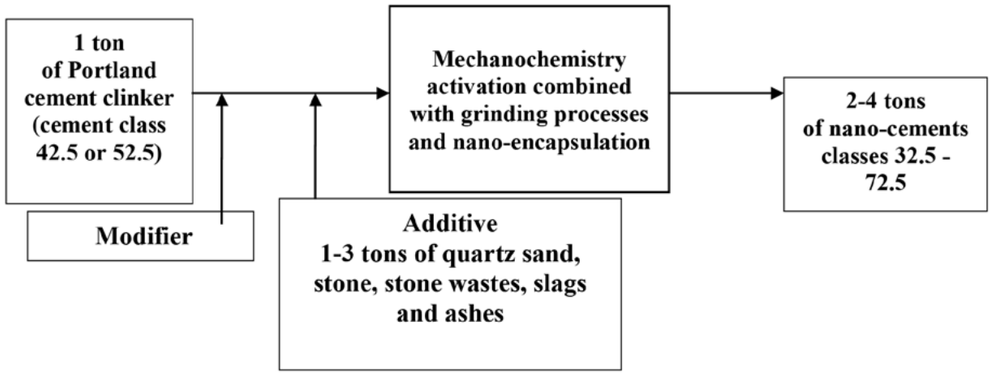

Fig. 1. Technological scheme of low-clinker nano-cements production

MATERIAL THE NOVELTY AND UNIQUENESS

Nano-cement is cement produced via combined grinding processes in ball mills of the portland cement clinker or portland clinker and organic modificators, in which clinker particles are in covers (capsules) of structured modificator with a thickness of dozens of nm, with silicate mineral supplements, approximate to cement grains according to grain size analysis, and also with set regulators in the form of ground cement with plaster or anhydrous gypsum (plaster) stone with GOST 4013.

Radically higher building-technical properties of nano-cements are explained by the formation of nanocover over cement grains during the modification process via mechanochemistry processing, compared with famous and widely used portland cements.

Nano-cement compressive strength class at the age of 28 days should be consistent with C 32.5; C 42.5; C 52.5; C 62.5; C 72.5 and C 82.5. The letter "C" means "capsule portland cement". The nano-cement types and composition depending on the content of portland cement clinker or portland cement are presented in Table 1

Nano-cement fineness of grinding over the specific surface, determined by the air permeability method using Blaine apparatus, should be no less than 400 m2/kg. Thickness of grains nanocover of the portal cement should be within 10 - 100 Nm.

THE PROSPECT OF THE NANO-CEMENT TECHNOLOGY

In 1986 -1991, Low water demand binders (nano-cements precursors) were elaborated in Russia on the base of modification of the portland cement that radically improves the technical properties of traditional portland cements.

More than 3 million tons of new cements were produced under government contracts in Belgorod cement plant and Zdolbunovsk cement-slate combine, and also on ten small process lines. After the collapse of the USSR, the production of the low water demand binders was preserved at the 81 reinforced concrete Combine in Samara, Moscow Combine of building products and materials, the State All-Union Research and Development Institute of the Cement Industry (NIICement) in Podolsk and Special enterprise #2 of Ecotechprom in Moscow, and last years the line with the capacity of 100 thousand tons of nano-cement has been developed in Sergiev Posad reinforced concrete constructions factory.

Millions of cubic meters of different concrete that have been effectively used in general and special building during the last 30 years, were produced on the base of the low water demand binder and its varieties. It's enough to indicate the production of nano-cement underground silos for intercontinental ballistic missiles, subway tunnels, sleepers, airfield and road slabs, piers and berths, original buildings and constructions (fig. 2-5).

The lack of stability of the building-technical properties of some producers and the absence of the uniform national legal framework impeded wider development of these cements in the manufacturing industry.

Positive results of the production technology and nano-cement tests in Russia, P.R. China, Saudi Arabia, the UAE and Brazil, energy-saving opportunities, reduction doubled or tripled unit costs of fuel and the $CO2_2$,NO_X and SO_2 emissions, for the first time in world practice production opportunities of cements classes 72.5 - 82.5, the high quality of nano-cements and concretes on its base approved for a long time, proven applicability up to 70% of mineral supplements in form of silicic rocks, ash and slags, usage efficiency of the off-quality nonmetallic feed for high quality cements and concretes production, provide the perspective of the larger scale production implementation of new technology in building industry of Russia and other countries with the adopted prestandart.

The wide prospect of the nano-cement technology is dictated by the key issues of the cement manufacturing of Russia, the UAE, P.R. China, India, Brazil and other countries — the need for significant increase in cement production, reduction doubled or tripled unit costs of fuel and the $CO2_2$, NO_X and SO_2 emissions, quality improvement and cost reduction of cement and concretes.

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Nano-cement types and composition **Table 1**

Classes strength	Abbreviated name (nano-cement type)	Main components*, mass %	
		Portland cement clinker	Mineral silicate supplements: slags (S), boiler fly ash (A), quartz sand (QS), slag waste (SW)
C82.5	NANO-CEMENT 90	90 - 98	2 - 10
C72.5	NANO-CEMENT 75	75 - 88	12 - 25
C62.5	NANO-CEMENT 55	55 - 74	26 - 45
C52.5	NANO-CEMENT 45	45 - 54	46 - 55
C42.5	NANO-CEMENT 35	35 - 44	56 - 65
C32.5	NANO-CEMENT 30	30 - 34	66 - 70

- * If it's necessary to retard the setting strength of cement paste, plaster stone or its analogs are introduced more than 100%.

Nano-cement physical-mechanical properties **Table 2**

Nano-cement class of strengths	Compressive strength, MPa, at the age of				Initial setting strength time, min, not earlier than	Soundness (expansion) mm, no more than
	2 days no less than	7 days no less than	28 days			
			no less than	no more than		
C 32.5	10	20	32.5	52.5	≥75	≤10
C 42.5	25	40	42.5	62.5	≥60	
C 52.5	30	50	52.5	72.5	≥45	
C 62.5	35	55	62.5	82.5		
C 72.5	40	60	72.5	92.5		
C 82.5	45	65	82.5	102.5		

Movement of cement-sand reinforced mortar **Table 3**

Nano-cement types	Fixed movement of cement-sand reinforced mortar by flow, mm	Nano-cement types	Fixed movement of cement-sand reinforced mortar by flow, mm
NANO-CEMENT 90	155 - 160	NANO-CEMENT 45	125 - 130
NANO-CEMENT 75	145 - 150	NANO-CEMENT 35	120 - 125
NANO-CEMENT 55	130 - 140	NANO-CEMENT 30	115 - 120

TEST NANOTSEMENTOV AND CONCRETE ON THEIR BASIS IN THE UNITED STATES, CHINA,UAE, SAUDI ARABIA, PORTUGAL AND BRAZIL

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Director General of
Moscow IMET

The present report provides the results of different tests of Nano-cements mortars and concretes on their basis for the past few years. The first test of Nano-cement oversea of Russia, were conducted in the 1989 in the laboratory of Portland Cement Association of the United States and Canada in (Skokie city) in the state of Chicago, USA. Details of the research and testing have been tested two types of Nanocements which called in Russian VNV — mean Low Water Binder — VNV 100 (100% of Portland cement without mineral additives) and VNV 50 (50/50 Portland cement and silica sand.

USA, CONSTRUCTION TECHNOLOGY LABORATORIES INC

The first test of Nanocement outside of Russia, were held in the USA in 1989, in the Construction Technology Laboratories Inc, (CTL) in Skokie city in the state of Chicago.

Details of the research and testing have been tested two types of Nanocements which called in Russian VNV - mean Low Water Binder- VNV 100 (100% of Portland cement without mineral additives) and VNV 50 (50 % of Portland cement and 50 % of quartz sand and granulated blast furnace slag in equal parts), milled together with Portland cement).

The purpose of the tests was to assess the effectiveness of Nanocements, their compliance with the standards of the American Society for Testing Materials (ASTM) and the determination of certain characteristics of concrete on their basis.

The choice of laboratory construction technology (CTL) for the certification of Nanocements (VNV), based on the recognition of its international prestige in the cement and concrete industry, high professional level of its specialists and equipped with the most modern instruments and equipment.

CTL Group is a daughter of self-supporting enterprise Portland Cement Association (PCA) of the USA and Canada and offers a wide range of services to various organizations in the field of research materials and structures during the expertise, provides advice to the survey of buildings and structures, etc.

For the tests in the United States by the Soviet side was delivered the required amount of binder of two kinds made on the basis of Portland cement clinker production of Zdolbunov cement plant, the chemical analyses of the samples are presented in Table 1.1(The content of alkali is determined by the formula $\sum$ alkali = Na_2O + 0,658 K_2O по ASTM C 150-8).

Definition oxide groups produced by fusion with Li BO at 1000°C. Determination of oxides using X-ray fluorescence analysis complies with ASTM C 114-85 to accelerate the test methods. The mineralogical composition of clinker is calculated in accordance with the requirements of ASTM C 150-85 a: C_3S - 46%; C_2S - 28%; C_3A - 6%; C_4AF - 11%. The content of TiO_2 and P_2O_5 in the calculation are summarized with Al_2O_3.

The chemical composition of the investigated cements

Table 1.1

Components oxides	Content, wt%.	
	Nanocement (VNV–100)	Nanocement 50 VNV-50)
SiO_2	21,93	40,08
Al_2O_3	4,50	5,16
Fe_2O_3	3,66	3,21
CaO	61,65	44,29
MgO	0,87	2,44
SO_3	0,45	0,26
Na_2O_3	0,56	0,58
K_2O	0,52	0,59
TiO_2	0,23	0,28
P_2O_5	0,10	0,09
Mn_2O_3	0,07	0,12
SrO	0,11	0,09
п.п.п.	3,78	3,35
Summary of alkali based on the Na_2O *	0,91	0,97

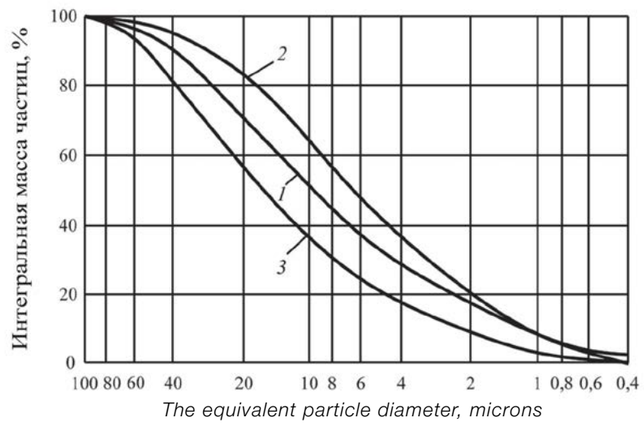


Fig. 1.1.

Particle diameter distribution:
1 - Nanocement (VNV-100 without mineral additives (S = 4900 cm2 / g);
2 - 50 Nanocement (VNV-50 with a 50% of mineral additive consisting of 25% mortar sand and 25% blast furnace slag (S = 5000 cm2 / g);
3 - Portland cement without mineral additive type I / II, USA (S = 4200 cm2 / g)

Fig. 1.1 shows the particle size distribution of US Portland type I / II and in the range of 0.1 Nanocements ... 100 microns. Comparison of the results of the mass distribution of the particles binding to their diameters for the reference of the American Portland Cement Type I / II and Nanocements revealed in their general character of a difference is the higher content of fine particles in test samples Nanocements. 15.7 and 55 microns. Fig. 1 shows the particle size distribution of USA Portland type I / II and Nanocements in the range of 0.1 ... 100 microns. Comparison of the results of the mass distribution of the particles binding to their diameters for the reference of the American Portland Cement Type I / II and Nanocements revealed in their general character of a difference is the higher content of fine particles in test samples of Nanocements which constitute 15.7 and 55 microns.

В табл. 2 представлены результаты определения основных физико-механических характеристик опытных образцов ВНВ по сравнению с требованиями стандарта ASTM к портландцементам. По большинству параметров опытные образцы ВНВ удовлетворяют или значительно превосходят требования стандарта.

In Table 1. 2 shows the results of determination of basic physical and mechanical properties of prototypes VNV compared with the requirements of ASTM standard for Portland cement. For most parameters prototypes of VNV, meet or exceeds requirements of the standard.Distinctive feature of the samples submitted for testing the samples of Nanocements was their low water demand for cement paste of normal consistency: an average of 16.5% for each of the submitted sample, the control sample of American Portland Cement had normal density of 26%.

Existing in the (CTL) aggregates were prepared two concrete compositions using no additional pure clinker Nanocement (VNV - 100) and Nanocement 50 (VNV - 50).

As fillers used conventional building sand from the deposit of "Elgin" density of 2.67 g / cm3 and coarse aggregate from the deposits of carbonate rocks "Thornton" maximum particle size of 10 mm and a density of 2.71 g / cm3 low quality, which is a porous rubble limestone unwashed structure.The composition of American experts appointed on the basis of receipt of medium- and high-strength concrete. For high-strength concrete binder accepted consumption 445 kg / m3 (sample without additional Nanocement) for concrete medium strength 30-40 MPa applied with Nanocement 50 (sample VNV-50), the flow rate of binder - 335 kg / m3.

The concrete mixture was prepared in a laboratory forced action mixer capacity of 60 liters adopted by (CTL) scheme: first mixed aggregates followed by about 15% of mixing water to wet the surface of fillers and binder and then added to the remaining water with stirring for 2 minutes. After holding for 2 min. the mixture was further stirred for another 3 minutes and then discharged.

During the test the concrete mixture is determined by the mobility of slump, air content in the compacted mixture, and the bulk density, was made by 18 cylindrical samples with a diameter of 10 cm and a height of 20 cm in disposable plastic molds. The samples were compacted by vibration table. Until the test they were stored under normal conditions. Table 1.2 show the compositions of the concrete mixtures.

The test results of the samples at 1, 3, 7 and 28 days. give a clear picture of the kinetics of curing concrete on the basis of Nanocements of different brands. US experts attracted their attention to the intensive growth of strength in the early stages of hardening that, in their opinion, is much accelerates the rate of concrete in the construction of monolithic structures and structures for various purposes.

In samples prepared on the basis of no-additional Nanocement (VNV-100) in (CTL), the tendency of some slowdown in recruitment strength after 3 days, compared with samples of other formulations. This is due to insufficient high strength of coarse aggregate used. When taking into account this factor to obtain concrete strength of 100 MPa is easy enough in the laboratory and in a production environment.

Thus, conducted in the USA to test new types of binders and concretes on their basis have confirmed their overall satisfaction, and by some measures and a significant excess of the requirements of US standards imposed on high-quality and fast setting cement. This demonstrates the potential competitiveness and the possibility of their use in the practice of construction.

The results of comparative tests Nanocements and ordinary portland cement, portland Lab Association of USA and Canada, the city of Shoki, (USA, April 1989)

Table 1.2

№ состава	Type Of binder	Расход материалов на 1 м³ бетонной смеси, кг				Additive content, wt.%	Slump, cm	Ultimate strength of concrete compressive normal curing (MPa) after:					
		Cement	Sand	Macadam	Water			16 h.	1 Day.	3 Days.	7 Days.	28 Days.	90 Days.
1	OPC-400	404	642	1155	189	–	4,0	–	8,9	13,6	22,3	32,6	34,8
2	OPC-400	412	676	1216	150	C-3; 0,7	4,3	–	18,2	34,8	43,9	48,6	51,4
3	Nano cement(VNV-100)	352	757	1250	126	-	4,8	41,3	52,5	67,7	75,3	88,1	114,3
4	Nanocement (VNV-50)	356	754	1244	128	–	17,0	18,0	23,1	42,6	57,8	64,4	68,9
5	Nanocement (VNV-100)	408	714	1284	112	–	5,4	44,4	54,5	76,7	82,6	92,4	108,4
6	Nanocement (VNV-50)	402	711	1279	112	–	4,5	16,8	30,4	48,7	61,3	72,3	77,8

Note: Samples of Nanocements made based on Portland cement according to Items 1

CHINA, CEMENT FACTORY IN SHIN-HUA IN JING-HUA, DZHEDZYAN PROVINCE

The optimal scheme for Nanocements keeping productivity of ball mills and therefore of acceptable specific energy consumption per ton of finished product is realized by us at the cement factory in Shin-hua in Jing-hua, Dzhedzyan province of China.

Said processing line includes an auxiliary crushing and milling equipment powerful press roll crusher - grinder type VSTM-2003 with capacity up to 150 t / h, drive power of 400 kW as the main grinding machine line includes - three-chamber tube ball mill 2,9 x11 m capacity of 50 t / h of the manufactured cement with mineral additives mark 32.5 standard ASTM-2003 China. In the pre-crusher - press rollers provide the all mixture components including Portland cement clinker and mineral supplements in the form of pieces (not more than 300 mm in diameter) without drying.

The gap between the rolls is about 40 mm. The addition of Chinese-made series FDN in dry form, injected into initial mixture, after pregrinding the components in press rolls to a size of 0 ÷ 25 mm and homogenizing the mixture in a mixer with forced mixing. Normal plant mixture composition: clinker - 63%; volcanic stone - 6%; slate - 16%; coal slag - 6%; Limestone - 7%; gypsum - 5%; A mixture of coal ash and limestone introduced in a weight ratio of 3: 2, the chemical composition of the mixtures is shown in Table. 2.1.

Before the start of each test tube mill unloaded due to its idling until the termination of the product out of it. In the first experiment, when ground was injected 1% by weight of cement. the modifier, in the second 0.8 wt.% in the third 0.6 wt%. the amount of mixture (Table 2. 2). The additive was injected in each case uniformly over 1 hr. 40 min. In each series of 11 samples were selected. The first trial was after 20 minutes, after the start of the feeding of the material, follow-up - 15 min.

As the results of the functioning of individual samples of the cement produced during the first series of tests with 1% by weight additive, the appearance of modifier in the mill leads to displacement of the particle size distribution range of cement into the area where have more dispersed values i.e. there is an increase of the grinding capacity of the mill (Table. 2.3).

Productivity of the mill was set by supply components made of cement and ordinary REGULATORY factory norm — 50 t / h. Similar in size mill in Russia have significantly different ball load, due to lack of material in the grinding mill before feeding.

During the tests revealed a significant effect the modifier FDN on the intensity of the cement grinding with mineral additives, so a fixed performance grinding line 50 t / h fineness of cement has increased significantly with the introduction of the modifier in an amount of 0.6-1% by weight of cement and an increase in supply quantity of volcanic stone (Table. 2.4.,2.5).

The chemical composition of the starting mixtures of components * for the production of Nanocements the city Jing-Hua, China

Table 2.1

№ п/п	Oxid	Content,% wt.					
		Clinker	Limestone	Coal slag	Slate	Gypsum	Volcanic stone
1	п.п.п.	0,65	42,44	6,63	8,3	14,18	6,58
2	SiO_2	21,77	2,01	55,1	55,35	10,67	70,42
3	Al_2O_3	5,04	0,55	9,35	9,8	0,48	13,98
4	Fe_2O_3	3,46	0,24	16,45	15,7	1,1	1,05
5	CaO	65,15	53,86	6,2	7,8	31,45	3,35
6	MgO	1,56	0,3	1,81	1,78	0,42	0,72
7	SO_3	0,96	–	1,02	0,56	41,29	0,44
8	W (water)	0,10	0,60	3,44	0,71	0,41	3,46

*** Definitions are made after drying the materials at 105 ° C**

Concentration of the components in the mixture for cement grinding

Table 2.2

№ п/п	Component	Content in the mixture,% wt.		
		Experiment №1	Experiment №2	Experiment №3
1	Clinker	63,0	40,0	33,0
2	Volcanic stone	6,0	18,0	28,0
3	A mixture of coal ash and limestone	10,0*	15,2*	21,4**
4	slate	15,0	21,0	12,0
5	gypsum	5,0	5,0	5,0
6	Modifier additive	1,0	0,8	0,6

*** The ratio of slag / limestone - 3: 2** The ratio of slag / limestone - 5: 2**

The introduction of modifiers intensifies the milling and radically increases the fineness of cement due to the micro-encapsulation highly dispersed grains of cement and prevent their aggregation. Analysis of the data obtained by graulometry of cements and in particular, the curves in Figure 2 show that the fineness of the particular intensity increases with increasing cement content of volcanic rock.

Increased bulk density observed when the concentration of the modifying additive in the mill increases and the period of its feeding, by reducing the porosity and increasing the index of dispersion of cement particles.

Water demand and cement setting time of individual test samples of the cement produced depend on the content of the clinker and the concentration of the modifier additives (Table 2.4).

These results demonstrate significant efficacy of mechanochemical treatment technology for the production of Low-Clinker Nanocements with mineral additives, allowing to reduce the clinker content of 30-40% by weight while maintaining high hydraulic cement activity, regardless of the excess moisture volcanic stone and coal slag.

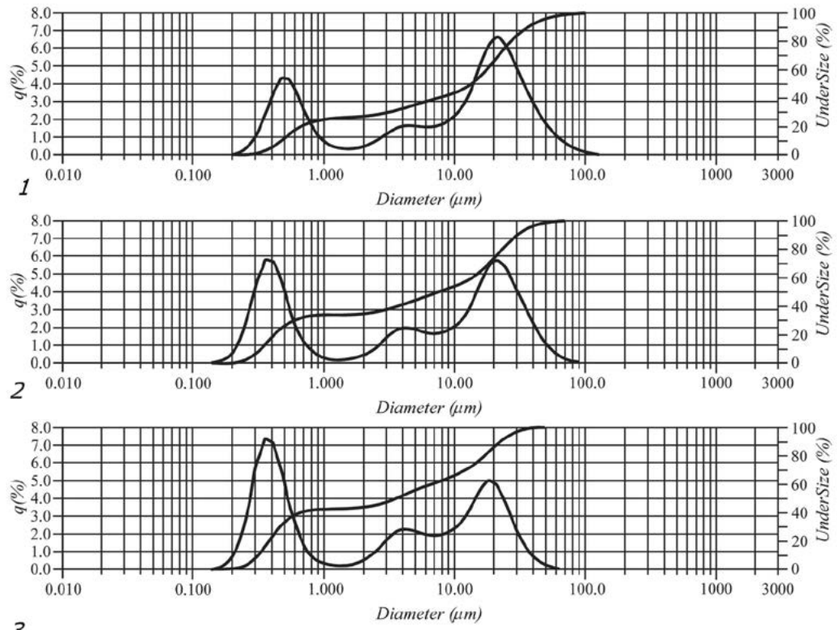
Especially impressive are the high values of the bending strength of cement stone on the basis of a 33% of clinker, reaching 12-13 MPa and associated with an increase in the content of highly volcanic stone in the Nanocement.

Specific surface area and average particle size of the samples Nanocements with mineral additives

Samples*	S, m^2/Kg	d, mic
1–3	548	4,13
1–6	556	4,07
1–9	518	4,37
2–3	730	3,10
2–6	783	2,89
2–9	691	3,27
3–3	792	2,86
3–6	936	2,42
3–9	771	2,93
Factory made	462	6,60

*** THere and further refer to samples: the first number - № of the experiment, the second number - № of sample selection s seen from the experimental results in the presence of the modifier, finer grinding of cement with mineral additives happening mainly due to grinding particles range 30-80 microns (Fig.2.1).**

Fig. 2.1.



Curves granulometry of industrial lots of Nanocements with mineral additives, Cement Plant Shin-hua, China:

1 - Experiment 1 - 63% clinker, and 1.0 wt%. modifier; 2 - Experiment 2 - 40% clinker, and 0.8 wt%. modifier; 3 - Experiment 3 - 33% clinker, and 0.6 wt%. modifier.

Interesting data were obtained by mechanical tests obtained Nanocements with mineral additives. Strength characteristics of standard beams made of sand-cement mixtures, depending on the content of the clinker and the concentration of the polymeric additive in the cement and the index of the water-cement ratio (Table 2.4). Setting time of cement 32.5 by Chinese standards: the beginning of ≥ 0:45 min .; end ≤ 10:00.

The test results of standard samples of normal hardening parties of Nanocements in the factory Shin-hua, China, April-May 2008

Таблица 2.4

№№ партий	Strength at different times normal hardening, MPa					
	Compressive			Bending		
	1 Day.	3	28 Days.	1 Days.	3 Days.	28 Days.
Experiment №1: clinker content - 63% modifier - 1, 0% by weight.						
1	25,5		54,9	4,9	6,5	8,8
2	24,6		55,2	3,9	6,7	9,2
3	21.3		59.0	3.2	6.3	9.1
4	33.1		66.7	7.1	8.4	10.9
5	32.6		64.6	6.6	7.4	10.2
6	26.8		58.6	7.4	7.5	9.8
7	24.9		**57.4**	**6.4**	6.8	9.2
8	23.7		**54.0**	**6.0**	6.6	9.2
9	20.5		52.7	5.1	6.6	8.8
Experiment №2: CLinker content– 40%, modifier– 0,8% by weight.						
10	18.7		41.7	3.4	5.1	7.1
11	17.6		40.2	3.2	4.7	7.0
12	15.2		40.2	3.2	4.6	7.0
Experiment №3: CLinker content– 33%, Modifier– 0,6% by weight.						
13	8.7		35.3	2.1	2.7	13.2
14	5.9		32.3	1.8	2.8	12.9
15	7.2		30.6	1.8	3.3	12.7
16	7.8		30.2	2.0	2.7	13.4
17	7.0		29.3	1.6	2.3	12.3
18	6.9		28.1	2.0	2.9	12.9

ABU DHABI NATIONAL CEMENT FACTORY IN ABU DHABI

Abu Dhabi National Cement Factory in Abu Dhabi. two types of Nano-cements (90 and 55) were tested the composition of the fine aggregate concrete mix in the Laboratory of cement plant: Abu Dhabi National Cement Factory, the results are listed in Table 3.1.

ADNC | Abu Dhabi National Cement Factory

Test report - Abu Dhabi National cement factory, UAE

Date of test: 16/01/2014.

http://www.ghantootgroup.com

S. NO	SAMPLE DESCRIPTION	CEMENT in gms	END SAND, gms	WATER, ml.	WEIGHT OF THE PRISM, gms	DAYS	FLEXURAL LOAD KN	FLEXURAL STRENGTH N/mm2	COMPRESSIVE LOAD KN	COMPRESSIVE STRENGTH N/mm2	COMPRESSIVE LOAD KN	COMPRESSIVE STRENGTH N/mm2	AVERAGE LOAD KN	AVERAGE STRENGTH N/mm2
1	A1 N90	450	1350	127	589	2	1,693	6,347	37,42	23,38	36,66	22,91	37,04	23,15
		450	1350	127	593	7	3,351	**12,565**	87,82	**54,88**	82,79	**51,74**	85,31	**53,31**
		450	1350	127	591	28	4,175	**15,658**	110,47	69,04	108,24	67,64	109,36	**68,34**
2	B1 N55	450	1350	125	588	2	1,673	6,275	35,17	21,98	34,73	21,70	34,95	21,84
		450	1350	125	590	7	3,651	**13,692**	78,13	**48,83**	79,20	**49,50**	78,67	**49,17**
		450	1350	125	592	28	3,52	13,200	94,97	59,35	96,91	60,57	95,94	**59,96**
3	A2 N90	450	1350	112,5	591	2	2,433	9,123	53,83	33,64	52,31	32,69	53,07	**33,17**
		450	1350	112,5	594	7	3,791	14,067	103,58	64,73	106,82	66,76	105,20	65,75
		450	1350	112,5	591	28	4,788	**17,956**	123,01	76,87	122,69	76,68	122,85	**76,78**
4	B2 N55	450	1350	120	582	2	1,222	4,581	29,65	18,53	28,16	17,60	28,91	18,07
		450	1350	120	586	7	3,221	**12,079**	74,69	**46,68**	73,22	**45,76**	73,96	**46,22**
		450	1350	120	587	28	3,298	12,367	89,36	55,85	87,16	54,47	88,26	**55,16**

UAE. GULF READY MIX PLANT & AL HOTY-STANGER LABORATORIES

At the request of the concrete plant (GULF READY MIX) in Abu Dhabi in the laboratory of (Al Hoty-Stanger Laboratories), were tested concrete composed from Nano-cement 55 production of Russia.

LABORATORY TRIAL MIX

Page 1 of 6

CONTRACTOR : M/S GULF READY MIX

CONSULTANT :

PROJECT :

CLASS OF CONCRETE:C40/50 RUWAIS MIX

Mix A

Mat.	Type	WT.Kg	Water Abs.%	Water Abs.Kg	Moisture %	Moisture Kg	Corrected Weight-Kg	Lab.Batch Weight-Kg
CEMENT	CEMENT	380					380	11.400
WATER	ADM	114					109.1	3.272
ADM-1							0	0.000
ADM-2							0	0.000
20mm	CR-ROCK RAK	624	0.5	3.1	0.1	0.62	621.5	18.645
10mm	CR-ROCK RAK	457	0.5	2.3	0.1	0.45	455.2	13.655
5mm	CR-ROCK RAK	561	0.7	3.9	1.5	8.36	565.5	16.964
D-SAND	Al Ain	437	0.7	3.0	1.8	7.81	441.8	13.253
TOTAL		2573.0		12.32		17.24		

DATE :19.03.2014

MIX REF. :

WORKABILITY & TEMPARATURE

TIME	MINUTE	SLUMP(mm)	TEMP(°c)
10:00	0	215	23.0
10:30	30	215	23.0
11:00	60	215	23.0
11:30	90	200	22.5
12:00	120	200	22.5

DENSITY & COMPRESSIVE STRENGTH

AGE	DENSITY Kg/m³	COMP-STR.N/mm²	REMARKS
24 HORS	2550	39.0	
3 DAYS	2600	58.5	
7 DAYS	2570-2560	65.5,68.0	
28 DAYS	2580-2580	76.0,71.0	

LABORATORY TRIAL MIX

CONTRACTOR : M/S GULF READY MIX
CONSULTANT :
PROJECT :
CLASS OF CONCRETE:40N/mm2 RAK

Mat.	Type	WT.Kg	Water Abs.%	Water Abs.Kg	Moisture %	Moisture Kg	Corrected Weight-Kg	Lab.Batch Weight-Kg
CEMENT	CEMENT	320					320	9.600
WATER	ADM	160					156.9	4.707
ADM-1							0	0.000
ADM-2							0	0.000
20mm	CR-ROCK RAK	571	0.5	2.8	0.1	0.57	568.7	17.062
10mm	CR-ROCK RAK	370	0.5	1.8	0.1	0.37	368.5	11.056
5mm	CR-ROCK RAK	669	0.7	4.7	1.2	7.97	672.3	20.170
D-SAND	Al Ain	396	0.7	2.8	1.6	6.29	399.5	11.986
TOTAL				12.08		15.20		
		2486.0						

DATE :17.03.2014
MIX REF. :GR40RAK

WORKABILITY & TEMPARATURE

TIME	MINUTE	SLUMP(mm)	TEMP(°c)
15:25	0	240	23.5
15:55	30	235	23.5
16:25	60	225	23.0
16:55	90	215	23.0
17:25	120	215	23.0

DENSITY & COMPRESSIVE STRENGTH

AGE	DENSITY Kg/m³	COMP-STR.N/mm²	REMARKS
24 HOURS	2550	15.5	
3 DAYS	2590	40.5	
7 DAYS	2540-2580	48.5,51.0	
28 DAYS	2550-2580	55.0,52.0	

PORTUGAL, CIPOR PLANT

I enclose the results of Nano-cement 55 (2nd sample - 1333E) performed on mortar and concrete (2 different compositions). This sample of Nano-cement 55 has a granulometric curve not unlike that of a Portland cement is composed of about 49% quartz and about 49.3% of a clinker with a majority alítica composition.

Cement received (2nd sample) had not hydrated as happened in the previous sample (1st sample 0691E) then maximum results from resistance to all ages, see Table 5.1.

The Nano cement is very plastic and has resistance mortar after 28 days 68.5 MPa with a ratio w/c of 0.30 used instead of the usual 0.50 to EN 196-1 typically required to achieve a good plasticity. Presents a good growth of resistance with age. See table 5.1.

Table 5.3 shows the results obtained with two different concrete compositions with one of 280 kg/m3 and with another one of 340 kg/m3 (see Table 5. 4).

Slumps are different because as I mentioned in E-mail sent to 26-3, we tested a relationship of w / c was 0.39 with the composition of 280 kg/m3 of Nano cement and the concrete was very dry, which prevented compaction, so we adding the water to obtain a good workability of the concrete, final value w/c = 0.50.With a composition of 340 kg/m3, was used w/c 0.33 we can got a compacted concrete slump of 50 mm.

With this 2nd composition the strengths have obtained better results (more cement and less w / c) The introduction of modifiers intensifies the milling and radically increases the fineness of cement due to the micro-encapsulation highly dispersed grains of cement and prevent their aggregation.

Analysis of the data obtained by graulometry of cements and in particular, the curves in Figure 2 show that the fineness of the particular intensity increases with increasing cement content of volcanic rock.

Increased bulk density observed when the concentration of the modifying additive in the mill increases and the period of its feeding, by reducing the porosity and increasing the index of dispersion of cement particles.

Water demand and cement setting time of individual test samples of the cement produced depend on the content of the clinker and the concentration of the modifier additives (Table 4).

Analysis of Nano grout

Table 5.1

	Новый Нано цемент **New Nano cement**	Предыдущий Нано-цемент **Previous Nano-cement**
N º образца № sample	1333E	0691E
% цемента % Cement	100	100
в/с (паста) w/c (paste)	0,30	0,33
пластичность plasticity	Вода, Water	Вода, **Water**
1день (МПа) 1day (MPa)	21,3	-
R3 дней (МПа) R3 days (MPa)	47,2	21,7
R7days (МПа) R7days (MPa)	60,3	39,0
R28 дней (МПа) R28 days (MPa)	68,5	47,8

Chemical composition / mineralogy of samples№ 2 Nano cement 55

Table 5.2

	Новый Нано цемент New Nano cement	Предыдущий Нано-цемент Previous Nano-cement	
	N.º образеца, sample	**1333E**	0621E
TGA, ТГА	влажность humidity (110ºC)	**0,47**	1,81
	PF (110-250ºC)	**0,24**	0,74
	PF (250-500ºC)	**0,44**	0,66
	PF (500-950ºC)	**0,81**	1,87
FRX	% P.Fogo	**1,48**	3,27
	% SiO2	**50,45**	48,28
	% Al2O3	**3,32**	3,32
	% Fe2O3	**2,92**	3,09
	% CaO	**38,17**	37,89
	%MgO	**0,49**	0,47
	%SO3	**1,89**	1,96
	% K2O	**0,52**	0,53
	% Na2O	**0,29**	0,31
	% TiO2	**0,21**	0,22
	% MnO	**0,04**	
	% SrO	**0,07**	
	Total (%)	**99,44**	99,34
Alpine	% R. 45 µm	**8,5**	8,7
	% R. 32 µm	**14,8**	13,8
	IP (minutos)	**275**	405
DRX	% Alite - C3S	**38,3**	41,0
	% Belite - C2S	**1,6**	4,7
	% C4AF	**4,8**	5,1
	% C3A cúbico	**2,2**	0,0
	% C3A ortorrômbico	**2,5**	3,4
	% Ca (OH)2 - Portlandite	**0,00**	1,4
	% Quartzo - SiO2	**49,1**	42,3
	% Ettringite	**0,00**	1,6
	% Microcline	**0,00**	0,5
	Gesso +Bassanite	**1,7**	-

Testing of concrete

Table 5.3

Новый Нано цемент New Nano cement		
	280 kg/m3	**340 kg/m3**
N º образца, № sample	1333E	**1333E**
Осадка мм, Slump (mm)	160	30
B/c, w/c	0,50	0,33
% захваченного воздуха, % of entrapped air	2,2	0,6
1день (МПа) 1day (MPa)	7,5	26,5
R3 дней (МПа) R3 days (MPa)	21,0	48,0
R7days (МПа) R7days (MPa)	24,0	55,0
R28 дней (МПа) R28 days (MPa)	35,5	65,0

Composition of concrete

Table 5.4

Кг/м3, Kg/m3	1336E	1337E	1338E	1339E	1340E
Нано цемент 55 Nano-cement 55	Щебень 2 macadam 2	щебень 1 macadam 1	рисовая шелуха rice husk	Крупный песок coarse sand	Тонкий песок Fine sand
280	550	280	260	380	440
340	570	280	260	390	360

BRAZIL. VOTORANTIM CEMENT PLANT.

1. Materials characterization

1.1. X-Ray Fluorescence

Table 6.1
Chemical composition

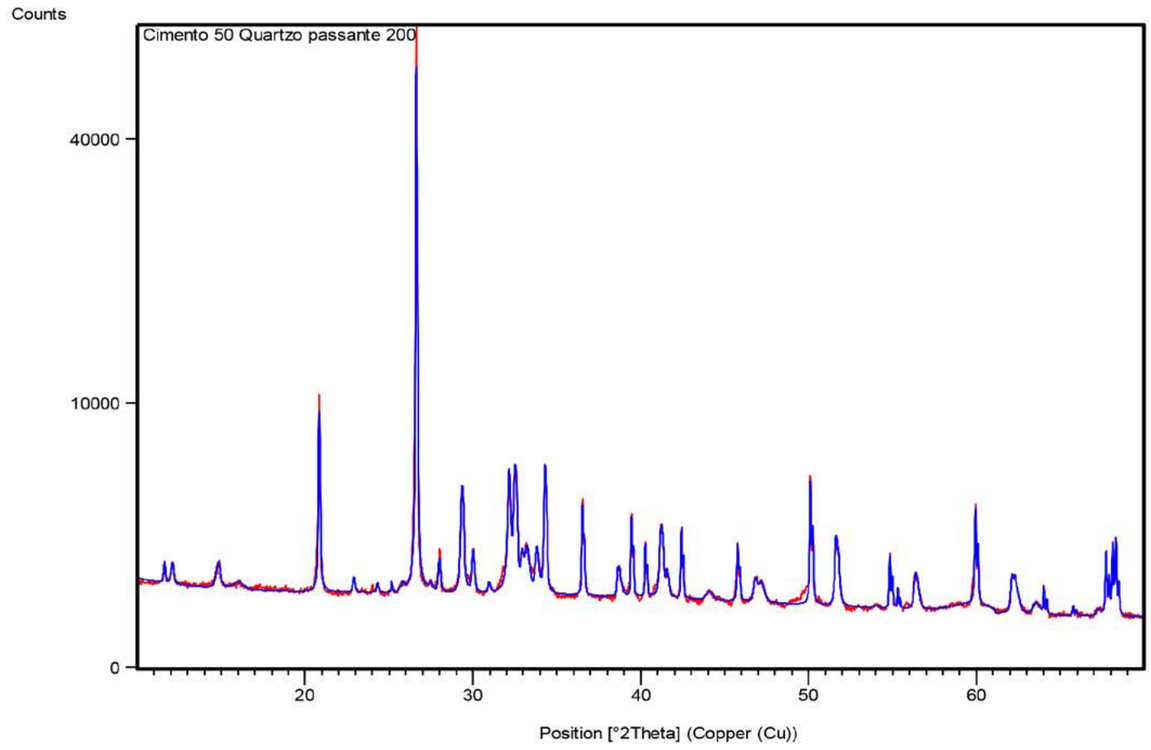
	Nano-cement	(OPC 42,5) cement
SiO2(%)	55,23	20,13
Al2O3(%)	3,19	5,23
Fe2O3(%)	3,42	2,65
CaO(%)	35,09	57,95
MgO(%)	0,40	5,97
Na2O(%)	0,32	0,14
K2O(%)	0,48	0,82
SO3(%)	1,60	2,92
Mn2O3(%)	0,058	0,158
P2O5(%)	0,08	0,10
TiO2(%)	0,27	0,25
ZnO(%)	0,04	0,01
Cr2O3(%)	0,03	0,03
SrO(%)	0,11	0,06
PF	1,85	4,00

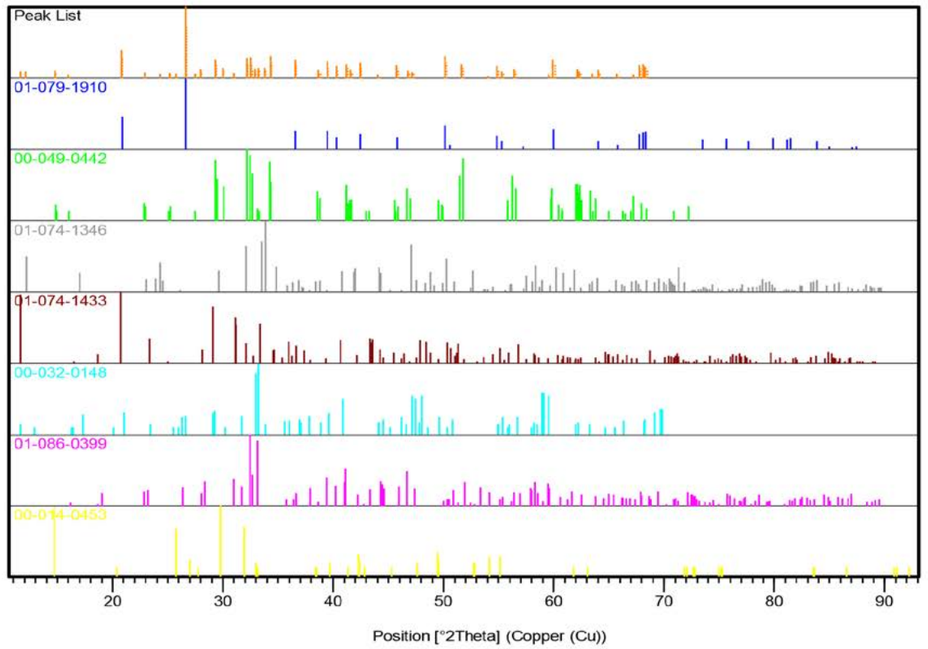
Nano-cement s mineralogy identified by XRD

Table 6.2

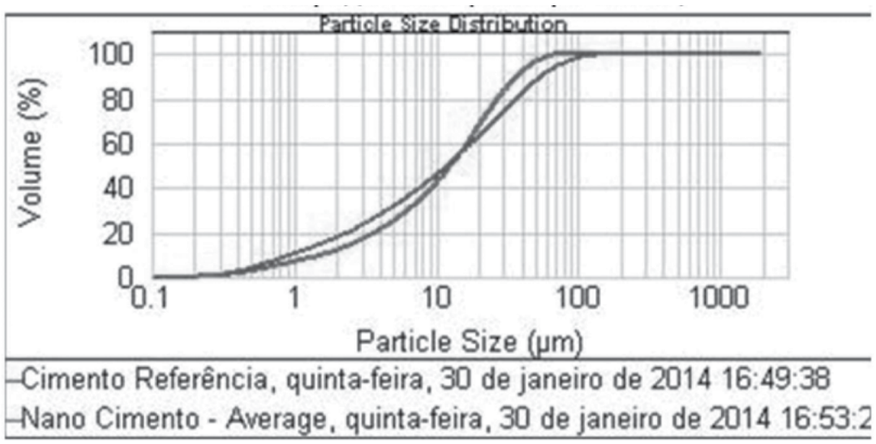
Ref. Code	Compound Name	Scale Factor	Chemical Formula
01-079-1910	Silicon Oxide	0,929	SiO2
00-049-0442	Calcium Silicate	0,069	Ca3SiO5
01-074-1346	Iron Aluminum Calcium Oxide	0,027	FeAlO3(CaO)2
01-074-1433	Calcium Sulfate Hydrate	0,018	Ca (SO4)(H2O)2
00-032-0148	Calcium Aluminum Oxide	0,044	Ca3Al2O6
01-086-0399	Calcium Silicate	0,064	Ca2(SiO4)
00-014-0453	Calcium Sulfate Hydrate	0,009	CaSO4.5H2O

Difractrogram of Nanocement





Laser Granulometry



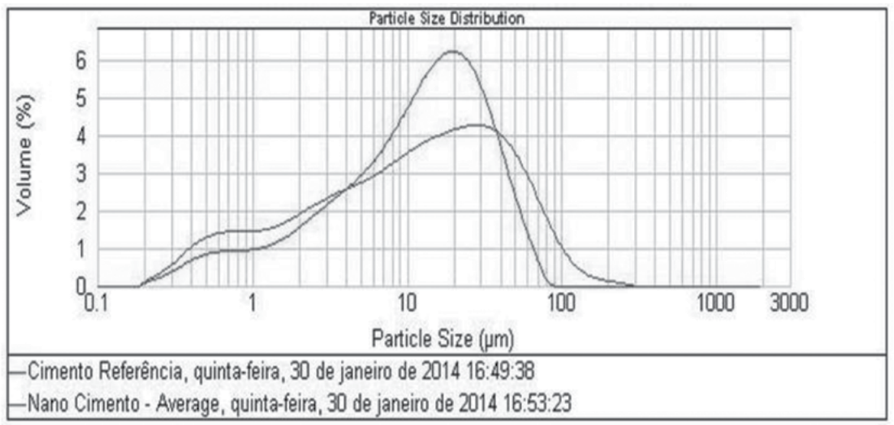


Figure 6.2 and 6.3 – Particle size distribution of Nano-cement 55 and (OPC 42,5) cement

Table 6.3 – Flow-ability of pastes made with Nano-cement and (OPC 42,5) cement

	конус (mm)	Цемент (г)	Вода (мл)	В/Ц
Прототип- цемент	137,5	150	90,0	0,600
Наноцемент 55	162,5	150	37,5	0,250

Table 6.4 – Performance of Nano-cement 55 and (OPC 42,5) in mortar по суткам

	растекаемость (мм)	В/Ц	1 сут, МПа	7сут, МПа	28 сут, МПа
Прототип - портландцемент	184	0,481	17,1	35,3	45,8
Наноцемент 55 с 230г H_2O	223	0,369	10,6	37,8	44,0
Наноцемент 55 с 225g H_2O	182	0,361	9,55	43,2	55,2

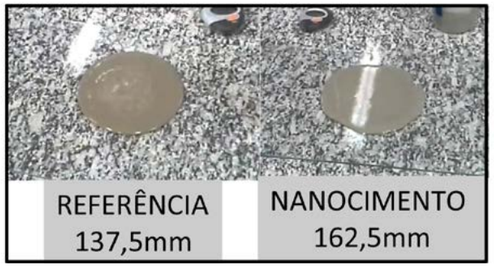
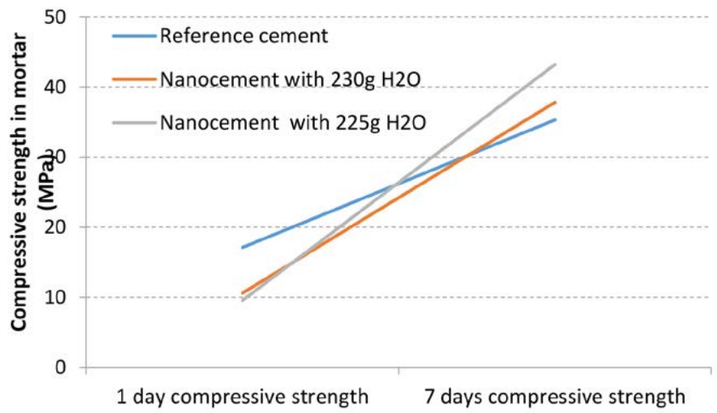


Figure 6.4

Flow ability of Nano-cement and (OPC 42,5) cement measured by Kantro s cone

Figure 6.5

Compressive strength of Nano-cement 55 and (OPC 42,5) cement measured according to the Brazilian standards



ECONOMY EVALUATION OF THE NANO-CEMENT PRODUCTION MANAGEMENT

Shykun V.N
Deputy Managing Director Operations of
"Moscow IMET" Public Corporation

Economic effectiveness of the realization of new modification technology of the Portland cement into nano-cement is formed from the replacement with a significant volume (up to 70-80% mass.) that is the most expensive in the Portland cement — clinker part — by different silicic rocks and alumo-silicic rocks.

Such rocks are, in particular, quartz-contained fine-grained sands that are unusable for building and concrete production, but distributed world-wide, for example, eolian sands from the Arabian Peninsula deserts, North of Africa, Middle Asia and other regions, and also some other volcanogenic natural stones and basic alumo-silicic rocks. The cost of such a nonmetallic feed is the lowest that makes it quite appropriate for the low-clinker cement technology.

The second raw source for the low-clinker cement technology is various wastes like slags, ashes, and processing of rocks - volumes of which reached hundreds billion tons and became the problem for ecology preservation in many developed and developing countries. In this case, using them as the components of low-clinker nano-cements we obtain trifecta:

- industrial wastes (up to billion ton) are effectively processed (into necessary product for building);

- cement volumes increase on the planet without payments for cement plants construction and creation here branches for clinker burning;

- without any necessity to create new limestone and clay quarries that seriously affect the nature;

- large (hundreds million tons) fuel volumes, used for clinker burning, are saved, and atmospheric emission of pollutants CO_2 , NO_X and SO_2 are eliminated.

In the report of acad. BICKBAU M.Ya. was demonstrated a table with basic calculation of economy effectiveness of low-clinker nano-cements technology - you can see it in the materials of our seminar-conference. It shows the possibility of saving under the condition of Russian cement plants. $25-15 per each ton of the high-quality cement, depending on nano-cement classes. At that the possibility of significant selling price growth for nano-cements 62.5; 72.5 and 82.5 classes that are produced nowhere, except Russia.

In Table 1 we show the results of calculations of economy effectiveness of nano-cements, made by Mr. Ikhlef Bualem and our colleagues in the UAE for the working conditions of the plants with capacity 500 000 of nano-cement per year.

These calculations, based on the processing of foreign cement or clinkers, prove the high effectiveness of the new nano-cement technology for the UAE, accomplishment of progressively increasing demand of cement for building enterprises, can be made via the reduction of cement import from other countries, only due to the development of milling branches of modern cement plants.

We made the calculations in two variants: through the example of capacity increase from 570 000 tons of cement to 1 million tons per year for Bakhchisaray cement plant in the Crimea Republic, RF, and for the building of enterprise for modification (milling) of foreign cement or clinker into nano-cement with the capacity 300 000 tons per year under the condition of Kaliningrad region, RF.

BAKHCHISARAY CEMENT PLANT IN THE CRIMEA REPUBLIC

Our offers concerning the plant modernization will allow providing annual output of app. 1 million ton of nano-cement instead of todays 570 000 tons by Bakhchisarai cement plant with utilization of cement clinker volumes, now produced (370 000 tons) and without the construction of burning production area due to the increasing of capacity of the plant milling branch. The offers are initiated and elaborated by the Moscow Institute of Material Sciences and Enabling Technology, Public Corporation, and enterprise "SpetsPodvodStroy", Kiev, Ukraine.

It is offered the effective nano-cement production method without construction of full-sized plant with furnaces and quarries, with investments per ton of the new product not $200-400, but $30-50 (in offered project no more than $40 per cement ton). At the same time, there's no need to search for big land plot and exploring raw materials quarry for producing cement, there's no big fuel consumption for clinker burning and there are no emissions of CO_2 , heat and dust. New technology enables to obtain 2-2.5 times more high-quality construction material from the available volumes of clinker.

Project realization will allow:

- in a short time to provide the construction industry with high quality cement for Republic of Crimea;

- increase the volume of cement needed to Republic of Crimea, especially for the urban regeneration of South-East of Ukraine;

- to develop the production of the wide range of ferro-concrete constructions for non-steel formation of prefabricated buildings and constructions according to the shoring architectural construction system of 'Moscow Institute of materials science and efficient technologies' and cluster roads according to the transport construction system of 'Moscow Institute of materials science and efficient technologies' (pillars, plates, panels, flyovers components etc.) as well as cast artificial stone (fill-out materials, road and sidewalk pavements, small architectural forms), bulking construction mixtures, concrete and ferroconcrete products);

The offered technology of nano-cement production entails joint grinding and mechano-chemical activation combined with nano-encapsulation with special polymeric substance, particles of Portland cement clinker or ready-made cement that enables to introduce mineral additives in the cement in big percentages of the cement mass, to provide high grade of the material and significantly reduce unit fuel costs per a ton of cement with mineral additives.

Production of nano-cements will be carried out through the stream technology of production accepted in the cement industry. The production of nano-cement is based on the following principles:

- direct fluid. Horizontal, linear, raw materials, semi-products are periodically moved to the working posts by conveyer mechanisms.

- rhythmicity. Repetition of every operation and all technological process in the adequate time intervals.

- continuity. Every further operation of the process starts after the completion of the previous one. Equipment and operating staff don't stand idle.

Изготовление наноцементов будет производится принятым в цементной промышленности поточным способам производства. Производство наноцемента основывается на следующих принципах:

The technology of the developed automated complex will enable to get:

- nano-cements of all classes;

- precious and special cements;

- low active adhesives using technological wastes (burnt wood, rocks from collieries, ash and slag wastes, granulated slag).

Types and main parameters of nano-cement according to the national pre-standard 19-2014 adopted by the Russian Standard of the Russian Federation are presented in Table 2.

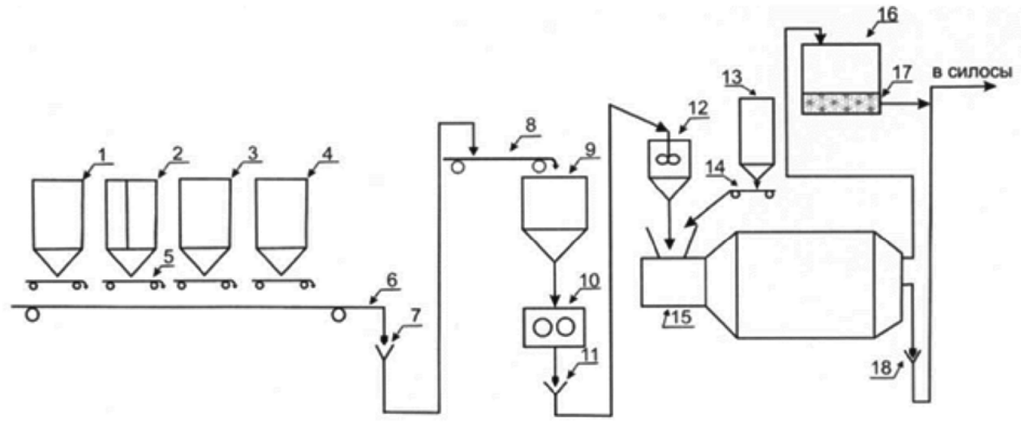
Bakhchisarai cement plant in the Crimea Republic mobile scheme of the equipment of the technological production line of nano-cements with ball mill 2.6 X 13 m. (Figure 1):

1-3.Bins for mineral supplements and plaster. 4.Bin for clinker. 5.Weight batchers (strain-measuring). 6,8.Band type conveyors. 7,11,18.Chain elevators. 9.Bin feeder. 10.rock pulverizer. 12. Bin feeder with impeller for mix homogenizing. 13. Modifier bin feeder. 14. Proportioning belt. 15. Ball mill. 16. Fabric filter. 17. Screw

Years of study and tests of the OJSC 'Moscow Institute of materials science and efficient technologies' allowed to prove the compulsory directed formation of the nano shells of modificatory on the Portland cement grains with mechano-chemical activation as the key condition of stable production of high-quality cements of new generation that ensure high technical construction properties of the nano-modified Portland cements called nano-cements.

Positive results of the production technology and nano-cement tests in Russia, P.R. China, Saudi Arabia, the UAE and Brazil, energy-saving opportunities, reduction doubled or tripled unit costs of fuel and the CO_2, NO_X and SO_2 emissions, for the first time in world practice production opportunities of cements classes 72.5 - 82.5, the high quality of nano-cements and concretes on its base approved for a long time, proven applicability up to 70% of mineral supplements in form of silicic rocks, ash and slags, usage efficiency of the off-quality nonmetallic feed for high quality cements and concretes production, provide the perspective of the larger scale production implementation of new technology in building industry of Russia and other countries.

Figure 1



1-3.Bins for mineral supplements and plaster. 4.Bin for clinker. 5.Weight batchers (strain-measuring). 6,8.Band type conveyors. 7,11,18.Chain elevators. 9.Bin feeder. 10.rock pulverizer. 12. Bin feeder with impeller for mix homogenizing. 13. Modifier bin feeder. 14. Proportioning belt. 15. Ball mill. 16. Fabric filter. 17. Screw

Cement strength classes

Table 2

Cement strength classes	Abbreviated name (nano-cement type)	Main components*, mass %	
		Portland cement clinker	Mineral silicate supplements: slags (S), boiler fly ash (A), quartz sand (QS), slag waste (SW)
C82.5	NANO-CEMENT 90	90 - 98	2 - 10
C72.5	NANO-CEMENT 75	75 - 88	12 - 25
C62.5	NANO-CEMENT 55	55 - 74	26 - 45
C52.5	NANO-CEMENT 45	45 - 54	46 - 55
C42.5	NANO-CEMENT 35	35 - 44	56 - 65
C32.5	NANO-CEMENT 30	30 - 34	66 - 70

- * If it's necessary to retard the setting strength of cement paste, plaster stone or its analogues are introduced more than 100%.

The fineness of the nano-cement grinding on the unit surface determined through the breathability method on the device PSX will be at least 400m2/kg. The thickness of the shell in the Portland cement grains will range from 10 to 100 nm.

The new material successfully underwent all stages of testing and for the first time in world practice ob-tained certification as the nano-product on the base of integrating testings "NANOCERTIFICA" LLC at the RUSNANO Corporation with the State Unitary Enterprise "NIIMOSStroy", MC "RUSNANO" and other organiza-tions.

It became one of the first national pre-standards for innovative construction materials approved in December 2014 by Russian Standard. National preliminary standard PNST RF 19-2014 'Nano-modified Portland cement. Technical conditions'.

The preliminary national standard was developed due to the wide commercial introduction of new types of the Portland cement - the general-purpose nano-cement, made on the base of the modified Portland cement that has undergone successful industrial tests.

MARKETING PLAN

The Backchisaray cement plant is the unique producer of cement in the Republic of Crimea. The suggested project of nano-cement production is sustainable to the actions of competitors due to the originality of the product (revenues increase due to the new range of cements with low cost price).

The indicated advantages aren't available among any producers of cements in Russia, Turkey and Republic of Ukraine. The organization of distribution of high-quality cements is certain. The priority of the producer over the sellers is the constant reserve of product in the storage, organizing supplies in necessary volumes and in the fixed time frames.

STATE SUPPORT AND LEGISLATION, INVESTMENT ADVANTAGES

Advantageous location resulting from the proximity to Western markets. Transit communications are the shortest way that connects Crimea, Russia, Ukraine, Turkey and west European countries.

Creating favorable regulatory framework for investors particularly defining possible incentives.

Commitment of the authorities to the market reforms.

Availability of raw materials and strong human capacity.

Relative social stability and absence of national antagonism.

In conformity with the offer of out partners, the cost of the equipment set, devices for the plant with the productivity of 500 thousand tons per year amounts to $10 million. Bearing in mind the transportation, in-stallation of equipment, construction and assembly operations at the site, infrastructure works and purchase of transport and handling equipment, the total cost of the nano-cement production project with 500 thousand tons capacity is about $17.5 million (Table 4)

ANALYZING WEAK AND STRONG POINTS OF THE PROJECT

In order to determine strong and weak points of the project the SWOT-analysis has been carried out. The results are presented in the Table 3:

	Advantages	**Disadvantages**
INTERNAL FACTORS	• Deficit of high-grade cements; • Absence of the enterprises that produce nano-cements; • New production technology (patent); • Processing possibility of foreign clinker or Portland cement	• Materials novelty
	Risks	**Possibilities**
EXTERNAL FACTORS	• Appearance of major competitors; • Appearance of product-replacements; • Product ramp-down; • Risks that are connected with increasing of the construction terms; • Political risks in the Crimea Republic; • Force-major factors.	• Volume increasing of cement production and creation of additional manufacturing; • Taking over the stable niche in the cement market; • Export developing abroad; • The possibility of participation in the Project for Ukrainian, Russian and foreign partners.

In conformity with the offer of out partners, the cost of the equipment set, devices for the plant with the productivity of 500 thousand tons per year amounts to $10 million. Bearing in mind the transportation, installation of equipment, construction and assembly operations at the site, infrastructure works and purchase of transport and handling equipment, the total cost of the nano-cement production project with 500 thousand tons capacity is about $17.5 million (Table 4)

Estimating financial needs for the construction of the nano-cement production with 500 thousand tons capacity per year in the Republic of Crimea.

Table 4

No. Item No.	Name	AMT	Cost million U.S. $
1.	Cost of the equipment for the nano-cement production with 300 thousand tons capacity per year.	Equipment set	8.90
2.	Project and exploration works' cost, getting approvals and providing technical conditions.	Set of documents	0.27
3.	Transport expenses for delivering equipment to the Republic of Crimea including reloading and delivering to the installation site	-	0.09
4.	Purchasing laboratory equipment, devices, handling and transport machines and mechanisms that ensures warehousing works and delivery of the cement to the consumer	Under the draft	0.58
5.	Construction and installation works, provision of engineering and electric networks, construction of transformer substation and access roads.	Under the draft	4.68
6.	Production of non-standard equipment on the installation site of the basic equipment including installation and overlay works.	Under the draft	0.79
7.	Pre-starting adjustments, acceptance of the technological line and all facilities on the 'turn-key' basis to the state committee.	3,0% от пп.1-6	0.46
8.	Acquisition of properties, infrastructure and land plots in the ownership of the company	-	1.36
9.	Unforeseen expenses, working capital for the initial period of the enterprise's work (percentage figures 5+6+7)	8%	0.47

Development of investments is expected to be carried out in three stages:

1st stage. Search and arrangement of the optimal industrial site at the territory of Backchisaray district, project and exploration works, completion of the project, excavation works, orders for equipment, engineering networks.

2d stage. Construction of the main block, starting installation works, construction of storage and auxiliary buildings.

3d stage. Construction of the complex of administrative and household premises, finishing installation of technical equipment. Pre-starting adjustments, completion of the enterprise.

The calculation of the unit costs for resources (raw materials) and reprocessing per unit of product (carried out by OJSC 'Moscow Institute of materials science and efficient technologies' in rubles according to the accumulated practical experience of nano-cements production in the Russian Federation. Having nano-cement cost price of $40-45 per ton and selling it at the average price of $50-60 per ton (current market price) we obtain income of $10-20 per a ton of nano-cement.

The calculation of expenses includes value components per a unit of the product when processing ready-made cement, for example M500 into 45:

Cement cost 3700 rubles per ton X 0.45 =
1665 rubles per a ton

Introduced sand cost 300 rubles per ton X 0.55 =
165 rubles per a ton

Transport expenses
(average - cement, sand) - 510 rubles per a ton
Electric power - 35 rubles per a ton
Fuel and lube oil materials - 3.2 rubles per a ton
Operating costs - 50 rubles per a ton
Salary and taxes - 55.9 rubles per a ton

Total: 2484.1 rubles per a ton ($41.4)

The calculation of expenses includes value components per a unit of product when processing cement clinker, for example into high-strength nano-cement 90 (class 82.5):

Clinker cost (90%) - 1440 rubles per a ton
Sand cost - 30 rubles per a ton
Plaster cost plus 5% - 850 rubles per a ton X 0.05 = 42.5 rubles per a ton
Transport expenses - 860 rubles per a ton
Electric power - 55 rubles per a ton
Fuel and lube oil materials - 1.9 rubles per a ton
Operating costs - 50 rubles per a ton
Salary and taxes - 55.9 rubles per a ton

Total: 2535 rubles per a ton ($42.2)

The sale value of such high-strength cements produced in the 'Consolit' plant in Podolsk (Moscow region) as VNV grade 700 (class 62.5) is about 12 000 rubles per a ton (currently $200)

When determining cost price of nano-cement via modification of the standard Portland cement the economy of the project is provided by increasing the volume of the end product by at least 50-55%, and finally the cost price of the produced nano-cement amounts to 2400-2500 rubles per a ton. The income of a ton of the sold nano-cement in grades 400-500 (classes 32.5-42.5) widely used in the construction amounts to 800-900 rubles per a ton ($10-15).

The expenses for processing and producing 500 thousand tons of product per year: 500 000 tons x 2 600 rubles = 1 300 000 000 rubles ($21.6 million)

Revenues from 500 thousand tons of product per year will be: 500 000 tons x 3900 rubles = 1 950 000 000 rubles ($32.5 million)

Net yearly profits will be: 1 950 000 000 rubles - 1 300 000 000 = 650 000 000 rubles ($10.8 million).

Therefore, if the project is accomplished in 12-14 months with project nano-cement production capacity 500 thousand tons per year the profitability of the project won't exceed 3-3.5 years including terms of construction.

CONCLUSION

The nano-cements technology offered in this project has been elaborated by the 'Moscow Insti-tute of materials science and efficient technologies' and its subsidiaries and is protected by the patents of the Russian Federation, international patenting and has been introduced in the volumes of several millions tons at the Belgorod cement plant and cement-slate plant in Zdolbunivsk during 1989-1991. Now, it's being used at the enterprises of Moscow, Chelyabinsk, Samara and other regions. Its implementation enables to produce cements with strength classes from 42.5 to 82.5. Besides, this technology increases several times real activity of Portland cement, and consequently the strength of the concrete is 1.5-2 times higher, significantly reduces and excludes steaming of concrete products. In winter conditions, this technology reduces the consumption of frost protection additives and the time of hardening of the concrete.

To the date, more than 3 million tons of nano-cements have been produced within the Russian Federation. These volumes allowed to produce millions of cubic meters of concretes that have been used efficiently in the civil and special construction for the last 30 years. It is enough to point out the production of launch mines for intercontinental ballistic missiles, underground tunnels, sleepers, aerodrome and road plates, piers and berths, original buildings and constructions on the basis of nano-cements.

Wide usage of such cements in the industry of the Russian Federation was prevented by the insufficient stability of technical construction properties of certain producers and absence of the unique regulatory framework within the country.

New technology allowed to elaborate adequate regulatory framework and approve national pre-standard 19 - 2014 'nano-modified Portland cement'.

The obtained technical construction characteristics of the nano-cement concretes prove the ability to rise radically the quality of concretes in Russia to the level exceeding world standards.

It's also important the energy saving while producing cements and improving concrete technologies. With this regard, it's to mention the prospect of production of low-clinker nano-cements that enables to reduce significantly unit energy expenses per a ton of cement due to the decrease of the Portland cement clinker contents in such cements to 30-35% saving high technical construction properties of the materials.

Nano-cement concrete mixtures have high mobility and good packing that enables to produce small and complicated components and forms. This characteristic is used to produce special constructions and products as well as decorative products, parts of ornaments and facades of buildings, sculptures etc. At the same time the quality of the surface is conserved, and it approximates to the natural stone materials with a broad range of colors and decorative solutions, including simulation of texture of natural stone (granite, marble etc.). Besides enumerated advantages, excellent consumer qualities of such concrete and its ability to be polished enable architects to construct buildings with high aesthetic expressiveness and decorate complexes with different architectural forms. This advantage of new cements with ability of polishing of mixtures and concretes in their basis as natural stone is extremely important for many guesthouses and rest houses in the Republic of Crimea.

Nano-cements will be very important for the modernization, reconstruction of roads, engineering structures, construction of airports, special and military objects in the Republic of Crimea and Sevastopol city as well as any other engineering buildings like skyscrapers, flyovers, bridges, tunnels etc.

The present business plan proves quick cost recovery of the project of nano-cement production and prospects, intensive implementation of new product using the example of Backchisaray plant in the Republic of Crimea, particularly in order to provide with nano-cement the construction of Kerchenskiy transport passage. Nano-cement can become exported product of the Republic of Crimea.

There can't be any doubts concerning economic efficiency of using new technology of modification of Portland cements in nano-cements in any country that produces cement - the main construction material.

ENERGY SAVING AND ECOLOGICAL COMPATIBILITY OF NANO-CEMENT PRODUCTION

Khasanov Nail
EVROCAM, MOSCOW, RF

The technology of the Portland cement modification into nano-cement allows to radically overview the development strategy of cement industry, gives the opportunity to reduce the unit costs of fuel and CO2, NOX, and SO2 emissions per every ton of cement 2-3 times with the minimal investment, at the same time resolving the problems of energy saving, ecology and increasing amount of high-performance concrete.

The new technology of Portland cement modification into the energy saving nano-cement during the grinding processes of clinker and cement remilling allows realizing the addition up to 70% mass. into cement, aiming at ensuring greater grade - class of such a low-clinker nano-cement no less than 42.5 with the reduction per each ton of cement for wet production method of the unit costs of fuel from 200 kg to 60 kg, and real CO2 emission from 1070 to 320 kg. So high results are reached due to the addition of cement 70% mass. of mineral supplement in the form of milled quartz sand that is considered as the most inert material, but in low clinker nano-cements in the active chemical interaction, and forms quick hardening, dense and strong cement stone.

Several years ago, the forecast of the U.S. Government informed that world emissions of carbon dioxide would increase by 75% up to 43.7 billion tons by 2030. The forecaster of the Energy Information Administration, the statistic branch of the US Department of Energy came to a conclusion.

The Reuters informed, according to the Administration experts, the CO2 emissions all over the world would increase from 29 billion tons in 2010 up to 43.7 billion tons by 2013 without additional reduction measures.

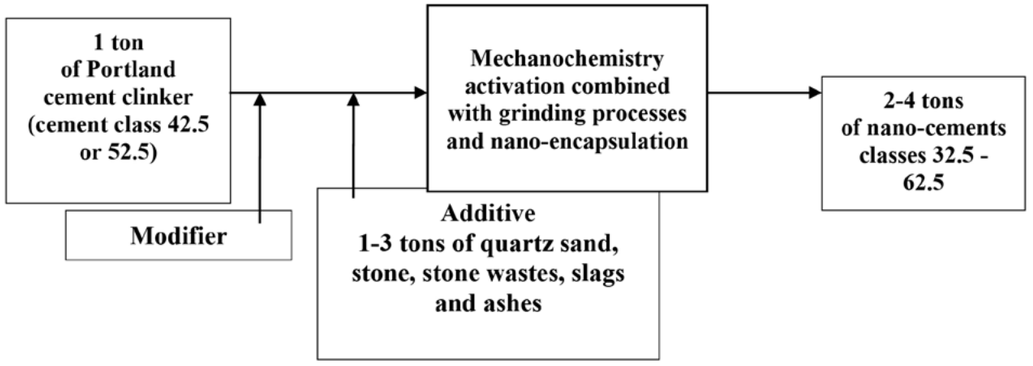
Many scientists share the same opinion that the increase of greenhouse gas emissions provokes rise in temperature and can lead to catastrophic changes such as heatwaves, hurricanes, and polar ice ablation, the result will be a 1 metre rise of global sea levels by 2100. Burning the fossil fuels - oil, gas, coal - releases the greatest amount of greenhouse gas. Increasing usage of coal as fuel in the USA, India, and China. In particular, in the developing cement industry it can overcome even oil in CO2 emissions during 2015-2030.

Nevertheless, forecasters didn't take into account the possible influence of the laws under consideration or draft laws, limitations or standards, including the international agreement concerning the reduction of emissions that is known as the Kyoto Protocol.

During 2008-2012 the 35 wealthiest countries that ratified the Kyoto Protocol are obliged to reduce the greenhouse gas emissions up to level 5% lower than their level in 1990.

Technological scheme of low-clinker nano-cements production

Fig. 1



Every year the production of significant cement volume requires hundreds million tons of fuel consumption and is attended by the significant emission of warm, CO_2, NO_X, and SO_2, that affect the climate change on the Planet. Only cement plants atmospheric emissions of CO_2 is app. 850 kg per each cement ton of dry method and app. 1000 kg of wet production method that every year equal to tens billion m^3 of toxic gas. Annually, new enterprises add to the thousands of cement plants in P.R. China, India, Latin America and other developing countries.

Improving of the Portland cement technology is realized in two key directions of the fuel unit costs reduction and the CO_2, NO_X и SO_2 emission:

- optimization of aggregative burning procession and grinding of the cement clinker;

- introduction of energy saving mineral supplements into the Portland cement.

The first direction of the world cement industry has reached significant successes - it has created the system high-performance equipment, warm utilization, air cleaning, etc. Engineering workers produce complete production lines with capacity from 3 to 4 million tons of cement every year.

The second direction, unfortunately, almost stopped its development. The average quantity of mineral supplements, introduced in the Portland cement, is app. 15% of its mass. Thus, the quantity of mineral supplements, introduced in 2013 at Russian cement plants, was app. 8% of mass. and reduced significantly during the last decades. At the same time, the world requirements documents of cement workers under the standard adopted in Europe: EN – 197-1 and ASTM in the USA provide more opportunities for the introduction of mineral supplements.

Thus, in the cements CEM III/A can be 36-65% of supplements, in CEM III/B 66 – 80 % and in CEM III/C 81 – 95 % of mineral supplements. In CEM Y/A it's recommended the introduction of 36 – 60 % of supplements, in CEM Y/B 64 – 80 % of mineral supplements.....

However, the cement plants all over the world don't hurry to work under the adopted standards and mostly produce the Portland cement without supplement CEM – of the I classes 42.5 and 52.5. This very important circumstance is connected with significant reduction of cement properties with mineral supplements. Due to this circumstance, the building organizations prefer to buy the Portland cement without supplements.

Experts, however, prevent the growth of mineral supplements volumes that are used with cement in the world: by 2020 - 26 % mass., by 2030 – 27 % mass. and by 2050 – 28 % mass.

Refinement of technical construction properties produced in the whole world of Portland cements shuddered to a halt for a long time and for several decades has not allowed increasing their activity, over classes 42.5 - 52.5 on durability. During several decades, cement plants all over the world have been producing almost the same product.

Russian scientists developed the technology of the Portland cement modification that allows radically increasing its building-technical properties and first of all cement grading strength (class) up to 92.5 - 102.5.

The content of the new technology of Portland cement modification into nano-cement leads in formation of full nanosized in thickness covers - capsules from special modifier - over Portland cement grains during the process of mechanochemistry activation combined with Portland cement size reduction.

The basic technological scheme of obtaining the energy saving low-clinker nano-cements with mineral supplements is shown in fig. 1.

The experience of more than 25 years of works on Portland cement technology modification into nano-cement, production of experimental-industrial and industrial lots of new material in the quantity several millions tons allowed to elaborate the nano-cements regulatory system for the first time in world practice.

The results of certification tests of nano-cements of various composition under the actual GOST demonstrated their full compliance with CJSC «IMET» TR - 5733-067-66331738-2012 «General-purpose nano-cement. Technical Conditions» elaborated by the affiliated company «Moscow IMET» Public Corporation. Nano-cements, saving the standard setting time, differ from basic Portland cement in greater specific surface, while fully maintaining the soundness and with significantly lower values of cement paste normal consistency (in average 17 - 20% instead of 26 - 27% of basic Portland cement). With such a low water requirement, cement and sand mixtures characterize by high workability (flow of all nano-cement compositions is 145 - 153 mm instead of 115 mm of original Portland cement - Table 1).

Taking into account the principal figures - hardening rate and compressive and deflection strength - all nano-cement compositions are better than ordinary Portland cement in all technical construction properties, allowing to improve cement class from 42.5 — 52.5 to 72.5 – 82.5.Under normal conditions nano-cement hardening rate is unprecedented for Portland cements. From there, the nano-cement 90 gives the opportunity to reach the record figures of cement stone in two days: compressive strength - 53.8 MPa, deflection strength - 7.1 MPa, nano-cement - 75 in 7 days of normal hardening allows to obtain compressive strength in stone - 68.5 MPa, and deflection strength - 8.0 MPa.

Very important is the intensive strength generation of the cement stone on the base of low-clinker energy saving nano-cements at the beginning of the hardening process. Consequently, the nano-cement 55 with only 55% mas. of nano-modified Portland cement demonstrated compressive strength in stone - 49.3 MPa, and deflection strength - 6.3 MPa in two days of normal hardening, reaching compressive strength - 77.5 MPa, and deflection strength - 8.2 MPa in 28 days of hardening (Table 1).

The results analysis of industrial production of various cements (Table 1) shows that nano-encapsulation technology allows to reduce three times the amount of expensive cement clinker and obtain brand strength of cement stone (in 28 days of hardening), supering that one for cement without supplements.

In fig. 1 are shown the results of certification tests of nano-cements of various composition, that were conducted in 2012 by SUE NIIMOSstroy with IIS NANO-CERTIFIKA, on the base of modified Portland cement PC-500 D ON «Oskoltsement» CJSC and mentioned ordinary Portland cement in different variations of its content from 90 to 30% mas.

Technical construction properties of nano-cement tested on the base of TU 5733-067-66331738 2012 “General-purpose nano-cement. Technical Conditions”. (Testing Laboratory the State Unitary Enterprise “NIIMOSStroy”, 2012)

Table 1

Name of test	Limited range of formability, MPa of samples of normal hardening						Nano-cover, thickness, nm	"Per unit" indicators** per cement ton, kg	
	of 2 days		of 7 days		of 28 days			fuel costs	CO_2 emission
	during deflection strength	during compressive strength	during deflection strength	during compressive strength	during deflection strength	during compressive strength			
Original Portland cement cement PC-500 DO-N "Oskoltsement" lot #654	**2.9**	**21.3**	**–**	**–**	**6.4**	**54.4**	**Absent**	**200**	**1070**
NANO-CEMENT 90* C 82.5	7.1	53.8	8.0	72.6	8.7	82.7	30-120	180	960
NANO-CEMENT 75 C 72.5	6.9	54.7	8.0	68.5	8.5	77.8	30-115	150	802
NANO-CEMENT 55 C 62.5	6.3	49.3	7.5	65.4	8.2	77.5	15-100	110	588
NANO-CEMENT 45 C 52.5	4.8	39.9	6.7	57.4	7.9	68.1	18-95	90	481
NANO-CEMENT 35 C 42.5	3.9	30.7	5.8	46.6	7.2	61.4	15-100	70	374
NANO-CEMENT 30 C 32.5	**3.0**	**20.4**	**5.6**	**46.4**	**7.6**	**52.1**	**14-85**	**60**	**321**

* - Figure hereinafter means the amount of Portland cement in nano-cement, the rest is the quartz sand floured with cement

** - Materials of mineral supplements are considered dry for simplicity of calculations, wet production method is registered for the basic cement

In 2012, six types of nano-cements were certified in IIS NANOCERTIFICA at the RUSNANO Corporation that proved full compliance of produced nano-cements TY – 5733-067-66331738-2012 General-purpose nano-cement. Technical Conditions.

For the first time in the world practice nano-cements were determined as nano-contained products of class B; the nanocover over cement grains was verified and Certificates of Conformance were obtained for nano-cements divided into classes according to quality: 82.5; 72.5; 62.5; 52.5; 42.5 and 32.5. These Certificates demonstrate safety data of production and nano-cement usage.

Firstly developed technology of low-clinker nano-cement gives the opportunity to reduce radically, 2-3 times, the unit costs of fuel and NO_X,SO_2 and CO_2 emissions per every ton of cement by reducing the content of the Portland cement clinker in such low-clinker nano-cements to 30-45% with saving of technical construction properties of Portland cement without any addition (Table 1).

Obtained nano-cements brand characteristics are the highest in the history of the world cement industry. Reached rates are the best achievement in cement technology in terms of energy saving and quality.

The industrial safety of productions and usage of nano-cement proved by the work and expert evaluations of the special organizations and obtained certificates of IIS NANOCERTIFIKA are very important.

New approach significantly changes the binders' perception of the cements potential, increases the efficiency of their application in the nano-encapsulation by 200%-300% and enables to use fine-dispersed mineral additives as active reagent for the cement stone formation. Nano-cements enabled to improve and develop understanding of the cement morphology and properties as well as their hardening and hydration abilities and to explain the process of the hydro-silicate cement stone inside the concretes with original microstructure created through the molecular layer deposition at the atomic and molecular levels.

Low-clinker nano-cements – nano-cements 30, 35, 45, 55 (Table 1) with high technical construction properties of the cements allow not only to reduce up to 2-3 times the unit costs and CO_2 emissions per a ton of cement but also to decrease significantly their production cost.

The production of nano-cements and concretes on their base allows to advance radically the improvement and production opportunities of more high-quality cements and concretes, energy saving and disposal of different industrial waste, usage of substandard non-metallic materials, significant reduction of the CO2 emissions with increasing production volumes of the modern building materials.

The improvement of the ecological environment also depends on the efficient application of low-linker nano-cements of the industrial waste such as slag, ashes from different energy enterprises, metallurgy and other industrial branches the waste heaps of which take large lands around big cities. The cement clinker is replaced in the cement by significant amounts of slag, ashes and fine sands that solves ecological problem connected with the recycle of industrial waste such as slag, ashes and substandard natural small and large concrete aggregates.

It is enough to point out that only in Russia the volumes of slag and ashes in waste heaps amounted to 80 billion tons and continued to grow in P.R. China, India as well as in other developing countries.

Therefore, the developed nano-cements technology allows solving comprehensively the energy saving problems in so energy-intensive branch as cement production as well as the problems of improving the qualities and the volumes of cement production – the main building material. It also allows improving ecological environment due to the efficient recycle of basic industrial waste heaps (slag and ashes) into low-clinker nano-cements.

The implementation of the low-clinker nano-cements technology gives a real opportunity to:

- reduce by 40-60 kg unit fuel costs per a ton of cement;
- radically improve the cement quality (1.5-2 times) during the reduction of its consumption in concrete;
- to increase 1.5-1.7 times the production in any cement plants without constructing clinker burning steps by only developing milling sections;
- to create compact processing lines for Portland cement clinker modification or cement into low-clinker nano-cements at the concrete production plants;
- to decrease specific N NO_X,, SO_2 and CO_2 emissions of the operating cement plants per a ton of nano-cement by 30-40%;
- extend the terms of possible nano-cements storage from 2 months up to a year or more according to Russian and international standards;
- reduce the cement production cost price by 20-25%;
- reduce the cost of the nano-cement concretes by decreasing Portland cement consumption and applying local non-metallic materials that allow to save between 500 and 1000 rubles ($15-30) per a cubic meter of the concrete mixture.

According to the technical construction properties, the obtained characteristics of the nano-cement concretes show the possibility to improve radically the quality of concretes in Russia up to the level exceeding the world indicators. When talking about energy saving, an important prospect in the cement production and improving concrete technologies are the prospects of the low-clinker nano-cements that gives the opportunity for radical specific energy cost reduction up to 35-45% of masses per a ton of cement due to the decreased Portland cement clinker contents maintaining the technical construction properties of the materials.
The development of nano-cement technology will allow to change the total development strategy of cement industry, increase 1.5-2.0 times the volumes of world cement production without building of new cement plants and raw material quarries, only due to increase in capacity of the grinding departments.

INDEPENDENT NONCOMMERCIAL ORGANISATION
"THE CENTRE OF CERTIFICATION OF PRODUCTION AND SYSTEMS OF MANAGEMENT IN THE SPHERE OF NANOINDUSTRY"

NANOCERTIFICA

CERTIFICATE OF COMPLIANCE

№ 0000050

№ РОСС RU.И750.НЖ02.000039 Validity term 10.12.2012 until 09.12.2015

OFFICE OF CERTIFICATION

OF PRODUCTS «NANOCERTIFICA» РОСС RU.И750.11НЖ02
10А, 60-year of October Av., Moscow, 117036 Tel./Fax: (495) 988-42-56, info@nanocertifica.ru

PRODUCTION OF NANOINDUSTRY

Nanocement of the general-purpose building, grade NANOCEMENT 90 C 82.5
Nanocontaining produce – category «B». Classification is on the backside of the certificate
ACP Code: 573320. Serial production

MEETS THE REQUIREMENTS

TC 5733-067-66331738-2012 «Nanocement of general-purpose building. Technical conditions»

MANUFACTURER

Enclosed joint-stock company «IMETSTROY» (EJSC «IMETSTROY»)
PSRN 1027700115298,127521, 17th Maryina Roscha passage 9, 127521 Moscow

THE CERTIFICATE WAS GIVEN TO

Enclosed joint-stock company «IMET» (EJSC «IMET»)
PSRN 1105262008345,121069, Merzliakovskiy Lane 15-5, Moscow
Tel: (495) 619-48-32, Fax: (495) 618-06-23, E-mail: moscowimet@mail.ru

ON THE BASIS OF

Of the Protocol No. 118/66 of 27.11.2012 EC «Mosstroyispytania» (РОСС RU.0001.21СЛ27).
Of the Protocol No. МС 170/1/56 (TEM) of 12.10.2012 «МС ROSNANO» LLC (РОСС RU.И750.НЖ01.21ИЛ04).
Of Inferences FBHO FCHaE of Rusconsumersupervision No. 16/07-4 FC of 03.10.2012 by results of classifying nanotechnologies and produce of nanoindustry by the degree of potential hazard, No 041 of 03.09.2012 by results of sanitary—epidemiological expertise by norms of radiation safety. Of the Act about results of the analysis of the state of the production No. СП-Ан-08/2012 of 04.10.2012. Of the Act of identification of produce of nanoindustry No. СП-Ан-08/2012 of 28.11.2012.

ADDITIONAL INFORMATION

Labeling of produce by the sign of compliance is made on the basis of «Procedure of the application of the sign of compliance of the System of voluntary certification of nanoindustry produce «NANOCERTIFICA».
Scheme of certification: 3a.

STAMP MANAGER OF THE OFFICE — Volkov S.Y.
Signature — Surname, Initials

CATEGORIES OF PRODUCTS OF NANOINDUSTRY

Category "A" - primary nanotechnology products
Category "B" - nanocontaining products
Category "C" - services which are produced using nanotechnologies and/or nanocomponents
Category "G" - special inventory for nanoindustry

PREFERRED CHARACTERISTICS OF THE GENERAL-PURPOSE BUILDING NANOCEMENT 90 C 82.5, OBTAINED DUE TO APPLICATION OF NANO TECHNOLOGIES

Name of the parameter (exponent)		Requirements of ND (TC 5733-067-66331738-2012)	Result of the tests	Test report
Times of setting, h-min	Beginning	Not less than 0-40 No more than 2-30	0-40	No. 118/66 of 27.11.2012 EC «Mosstroyispytania» (РОСС RU.0001.21СЛ27)
	Finish	Not less than 2-00 No more than 8-00	2-45	
Limit compressive strength, MPa	2 days	Not less than 42.5	53,8	
	28 days	Not less than 82.5	82.7	

Note: Characteristics of fast-hardening nanocement 90 (clinker content 90% by mass) correspond to the class C 82.5 by strength 900).

CHARACTERISTICS OF NANO-SIZE STRUCTURES, INCLUDED INTO A COMPOSITION OF THE GENERAL-PURPOSE BUILDING NANOCEMENT, NANOCEMENT 90 C 82.5

Name of the parameter (exponent)	Result of the tests	Test report
Presence of a nano-size polymeric shell on the surface of the particles of a cement	thickness 30-100 nm	No. МС 170/1/56 (TEM) of 12.10.2012 «МС ROSNANO» LLC (РОСС RU.И750.НЖ01.21ИЛ04)

CHARACTERISTICS OF THE SAFETY OF GENERAL-PURPOSE BUILDING NANOCEMENT, NANOCEMENT 90 C 82.5

Levels of potential dangerousness of product and technology Conclusions of Federal State-Funded Health care Institution and Federal Center of Hygiene and Epidemiology of Federal Service on Customers' Rights Protection and Human Well-being Surveillance No. 16/07-4 FC of 03.10.2012)	
By product value	By technology value
Low level of potential dangerousness for consumer	Low level of potential dangerousness of nanotechnology for workers, health, population and environment

INDEPENDENT NONCOMMERCIAL ORGANISATION
"THE CENTRE OF CERTIFICATION OF PRODUCTION AND SYSTEMS OF MANAGEMENT IN THE SPHERE OF NANOINDUSTRY"

NANOCERTIFICA

CERTIFICATE OF COMPLIANCE

№ 0000050

№ РОСС RU.И750.НЖ02.000040 Validity term 10.12.2012 until 09.12.2015

OFFICE OF CERTIFICATION

OF PRODUCTS «NANOCERTIFICA» РОСС RU.И750.11НЖ02
10А, 60-year of October. Moscow, 117036, Tel./Fax: (495) 988-42-56, info@nanocertifica.ru

PRODUCTION OF NANOINDUSTRY

Nanocement of general-purpose building, grade NANOCEMENT 75 C72.5
Nano-containing produce – category «B». Classification is on the backside of the certificate
ACP Code: 573320. Serial production

MEETS THE REQUIREMENTS

TC 5733-067-66331738-2012 «Nanocement of general-purpose building. Technical conditions»

MANUFACTURER

Enclosed joint-stock company «IMETSTROY» (EJSC «IMETSTROY»)
PSRN 1027700115298, 9, 17-th Proyezd of Mariina Roshcha, Moscow, 127521,

THE CERTIFICATE WAS GIVEN TO

Enclosed joint-stock company «IMET» (EJSC «IMET»)
PSRN 1105262008345, 15-5, Merzlyakovsky lane, Moscow, 121069,
Tel: (495) 619-48-32, Fax: (495) 618-06-23, E-mail: moscowimet@mail.ru

ON THE BASIS OF

Of the Protocol No. 119/67 of 27.11.2012 EC «Mosstroyispytania» (РОСС RU.0001.21СЛ27).
Of the Protocol No. МС 115/1/44 (ПЭМ) of 06.09.2012 «МС ROSNANO» LLC (РОСС RU.И750.НЖ01.21ИЛ04).
Of Inferences FBHO FCHaE of Rusconsumersupervision No. 16/07-4 FC of 03.10.2012 by results of classifying nanotechnologies and produce of nanoindustry by the degree of potential hazard, No. 041 of 03.09.2012 by results of sanitary-epidemiological expertise by norms of radiation safety. Of the Act about results of the analysis of the state of the production No. СП-Ан-08/2012 of 04.10.2012. Of the Act of identification of produce of nanoindustry No. СП-Ан-08/2012 of 28.11.2012.

ADDITIONAL INFORMATION

Labeling of produce by the sign of compliance is made on the basis «Procedure of the application of the sign of compliance of the System of voluntary certification of nanoindustry produce «NANOCERTIFICA».
Scheme of certification: 3a.

STAMP MANAGER OF THE OFFICE — Volkov S.Y.
Signature — Surname, Initials

CATEGORIES OF PRODUCTS OF NANOINDUSTRY

Category "A" - primary nanotechnology products
Category "B" - nanocontaining products
Category "C" - services which are produced using nanotechnologies and/or nanocomponents
Category "G" - special inventory for nanoindustry

PREFERRED CHARACTERISTICS OF THE GENERAL-PURPOSE BUILDING NANOCEMENT, GRADE NANOCEMENT 75 C72.5, OBTAINED DUE TO APPLICATION OF NANO TECHNOLOGIES

Name of the parameter (exponent)		Requirements of ND (ТС 5733-067-66331738-2012)	Result of the tests	Test report
Times of setting, h-min	beginning	Not less than 0-40 No more than 2-30	0-45	No. 119/67 of 27.11.2012 EC «Mosstroyispytania» (РОСС RU.0001.21СЛ27)
	finish	Not less than 2-00 No more than 8-00	2-40	
Concrete compressive strength, MPa	2 days	Not less than 40.0	54.7	
	28 days	Not less than 72.5	77.8	

Note: Characteristics of fast-hardening nanocement 75 (clinker content 75% is by mass) correspond to the class C72.5 by strength (grade 800).

CHARACTERISTICS OF NANO-SIZE STRUCTURES, INCLUDED INTO A COMPOSITION OF GENERAL-PURPOSE BUILDING NANOCEMENT, GRADE NANOCEMENT 75 К72.5

Name of the parameter (exponent)	Result of the tests	Test report
Presence of a nano-size polymeric shell on the surface of the particles of a cement	Thickness 30-100 nm	No. МС 115/1/44 (TEM) of 06.09.2012 «МС ROSNANO» LLC (РОСС RU.И750.НЖ01.21ИЛ04)

CHARACTERISTICS OF THE SAFETY OF THE GENERAL-PURPOSE BUILDING NANOCEMENT, NANOCEMENT 75 C72.5

Levels of potential dangerousness of product and technology Conclusions of Federal State-Funded Health care Institution and Federal Center of Hygiene and Epidemiology of Federal Service on Customers' Rights Protection and Human Well-being Surveillance No. 16/07-4 FC of 03.10.2012)	
By product value	By technology value
Low level of potential dangerousness for consumer	Low level of potential dangerousness of nanotechnology for workers, health, population and environment

INDEPENDENT NONCOMMERCIAL ORGANISATION
"THE CENTRE OF CERTIFICATION OF PRODUCTION AND SYSTEMS OF MANAGEMENT IN THE SPHERE OF NANOINDUSTRY"

NANOCERTIFICA

CERTIFICATE OF COMPLIANCE

№ 0000050

№ РОСС RU.И750.НЖ02.000041 Validity term 10.12.2012 until 09.12.2015

OFFICE OF CERTIFICATION

OF PRODUCTS «NANOCERTIFICA» РОСС RU.И750.11НЖ02
10A, 60-year of October. Moscow, 117036, Tel./Fax: (495) 988-42-56, info@nanocertifica.ru

PRODUCTION OF NANOINDUSTRY

Nanocement of general-purpose building, grade NANOCEMENT 55 C62.5
Nano-containing produce – category «B». Classification is on the backside of the certificate.
ACP Code: 573320. Serial production

MEETS THE REQUIREMENTS

TC 5733-067-66331738-2012 «Nanocement of general-purpose building. Technical conditions»

MANUFACTURER

Enclosed joint-stock company «IMETSTROY» (EJSC «IMETSTROY»)
PSRN 1027700115298, 9, 17-th Proyezd of Mariina Roshcha, Moscow, 127521

THE CERTIFICATE WAS GIVEN TO

Enclosed joint-stock company «IMET» (EJSC «IMET»)
PSRN 1105262008345, 15-5, Merzlyakovsky lane, Moscow, 121069,
Tel: (495) 619-48-32, Fax: (495) 618-06-23, E-mail: moscowimet@mail.ru

ON THE BASIS OF

Of the Protocol No. 120/68 of 27.11.2012 of EC «Mosstroyispytania» (РОСС RU.0001.21СЛ27).
Of the Protocol No. МС 168/1/56 (ПЭМ) of 12.10.2012 «МС ROSNANO» LLC (РОСС RU.И750.НЖ01.21ИЛ04).
Inferences FBHO FCHaE of Rusconsumersupervision No. 16/07-4 FC of 03.10.2012 by results of classifying nanotechnologies and produce of nanoindustries by the degree of potential hazard, No. 041 of 03.09.2012 by results of sanitary-epidemiological expertise by norms of radiation safety. Of the Act about results of the analysis of the state of the production No. СП-Ан-08/2012 of 04.10.2012. Of the Act of identification of produce of nanoindustry No. СП-Ан-08/2012 of 28.11.2012.

ADDITIONAL INFORMATION

Labeling of produce by the sign of compliance is made on the basis of «Procedure of the application of the sign of compliance of the System of voluntary certification of nanoindustry produce «NANOCERTIFICA».
Scheme of certification: 3a.

STAMP MANAGER OF THE OFFICE — Volkov S.Y.
Signature — Surname, Initials

CATEGORIES OF PRODUCTS OF NANOINDUSTRY

Category "A" - primary nanotechnology products
Category "B" - nanocontaining products
Category "C" - services which are produced using nanotechnologies and/or nanocomponents
Category "G" - special inventory for nanoindustry

PREFERRED CHARACTERISTICS OF THE GENERAL-PURPOSE BUILDING NANOCEMENT, NANOCEMENT 55 C62.5, OBTAINED DUE TO APPLICATION OF NANO TECHNOLOGIES

Name of the parameter (exponent)		Requirements of ND (TC 5733-067-66331738-2012)	Result of the tests	Test report
Times of setting, h-min	beginning	not less than 0-40 no more than 2-30	0-55	No. 120/68 of 27.11.2012 EC «Mosstroyispytania» (РОСС RU.0001.21СЛ27)
	finish	not less than 2-00 no more than 8-00	5-30	
Concrete compressive strength, MPa	2 days	not less than 30.0	49.3	
	28 days	not less than 62.5	77.5	

Note: Characteristics of fast-hardening nanocement 55 (clinker content 55% by mass) correspond to the class C62.5 by strength (grade 700).

CHARACTERISTICS OF NANO-SIZE STRUCTURES, INCLUDED INTO A COMPOSITION OF THE GENERAL-PURPOSE BUILDING NANOCEMENT, NANOCEMENT 55 C62.5

Name of the parameter (exponent)	Result of the tests	Tests report
Presence of a nano-size polymeric shell on the surface of the particles of a cement	Thickness 15-100 nm	No. МС 168/1/56 (TEM) of 12.10.2012 «МС ROSNANO» LLC (РОСС RU.И750.НЖ01.21ИЛ04)

CHARACTERISTICS OF THE SAFETY OF GENERAL-PURPOSE BUILDING NANOCEMENT, GRADE NANOCEMENT 55 C62.5

Levels of potential dangerousness of product and technology Conclusions of Federal State-Funded Health care Institution and Federal Center of Hygiene and Epidemiology of Federal Service on Customers' Rights Protection and Human Well-being Surveillance No. 16/07-4 FC of 03.10.2012)	
By product value	By technology value
Low level of potential dangerousness for consumer	Low level of potential dangerousness of nanotechnology for workers, health, population and environment

INDEPENDENT NONCOMMERCIAL ORGANISATION
"THE CENTRE OF CERTIFICATION OF PRODUCTION AND SYSTEMS OF MANAGEMENT IN THE SPHERE OF NANOINDUSTRY"

NANOCERTIFICA

CERTIFICATE OF COMPLIANCE

№ 0000050

№ РОСС RU.И750.НЖ02.000042 Validity term 10.12.2012 until 09.12.2015

OFFICE OF CERTIFICATION

OF PRODUCTS «NANOCERTIFICA» РОСС RU.И750.11НЖ02
10A, 60-year of October Av, Moscow, 117036, Tel./Fax: (495) 988-42-56, info@nanocertifica.ru

PRODUCTION OF NANOINDUSTRY

Nanocement of general-purpose building, grade NANOCEMENT 45 C52.5
Nanocontaining produce – category «B». Classification is on the backside of the certificate
ACP Code: 573320. Serial production

MEETS THE REQUIREMENTS

TC 5733-067-66331738-2012 «Nanocement of general-purpose building. Technical conditions»

MANUFACTURER

Enclosed joint-stock company «IMETSTROY» (EJSC «IMETSTROY»)
PSRN 1027700115298, 9, 17-th Proyezd of Mariina Roshcha, Moscow, 127521,

THE CERTIFICATE WAS GIVEN TO

Enclosed joint-stock company «IMET» (EJSC «IMET»)
PSRN 1105262008345, 15-5, Merzlyakovsky lane, Moscow, 121069,
Tel: (495) 619-48-32, Fax: (495) 618-06-23, E-mail: moscowimet@mail.ru

ON THE BASIS OF

Of the Protocol No. 121/69 of 27.11.2012 EC «Mosstroyispytania» (РОСС RU.0001.21СЛ27).
Of the Protocol No. МС 167/1/56 (ПЭМ) of 12.10.2012 «МС ROSNANO» LLC (РОСС RU.И750.НЖ01.21ИЛ04).
Inferences FBHO FCHaE of Rusconsumersupervision No. 16/07-4 FC of 03.10.2012 by results of classifying nanotechnologies and produce of nanoindustry by the degree of potential hazard, No. 041 of 03.09.2012 by results of sanitary-epidemiological expertise by norms of radiation safety. Of the Act about results of the analysis of the state of the production No. СП-Ан-08/2012 of 04.10.2012. Of the Act of identification of produce of nanoindustry No. СП-Ан-08/2012 of 28.11.2012.

ADDITIONAL INFORMATION

Labeling of produce by the sign of compliance is made on the basis of «Procedure of the application of the sign of compliance of the System of voluntary certification of nanoindustry produce «NANOCERTIFICA».
Scheme of certification: 3a.

STAMP MANAGER OF THE OFFICE Volkov S.Y.
Signature Surname, Initials

CATEGORIES OF PRODUCTS OF NANOINDUSTRY

Category "A" - primary nanotechnology products
Category "B" - nanocontaining products
Category "C" - services which are produced using nanotechnologies and/or nanocomponents
Category "G" - special inventory for nanoindustry

PREFERRED CHARACTERISTICS OF THE GENERAL-PURPOSE BUILDING NANOCEMENT, GRADE NANOCEMENT 45 C52.5, OBTAINED DUE TO APPLICATION OF NANO TECHNOLOGIES

Name of the parameter (exponent)		Requirements of ND (TC 5733-067-66331738-2012)	Result of the tests	Test report
Times of setting, h-min	beginning	not less than 0-40 no more than 2-30	1-45	No.121/69 of 27.11.2012 EC «Mosstroyispytania» (РОСС RU.0001.21СЛ27)
	end	not less than 2-00 no more than 8-00	3-50	
Limit compressive strength, MPa	2 days	not less than 22.5	39.9	
	28 days	not less than 52.5	68.1	

Note: Characteristics of fast-hardening nanocement 45 (clinker content is 45% by mass) correspond to the class C52.5 (grade 600).

CHARACTERISTICS OF NANO-SIZE STRUCTURES, INCLUDED INTO A COMPOSITION OF THE GENERAL-PURPOSE BUILDING NANOCEMENT, GRADE NANOCEMENT 45 C52.5

Name of the parameter (exponent)	Result of the tests	Protocol of the tests
Presence of a nano-size polymeric shell on the surface of the particle of a cement	Thickness 18-100 nm	No. МС 167/1/56 (TEM) of 12.10.2012 «МС ROSNANO» LLC (РОСС RU.И750.НЖ01.21ИЛ04)

CHARACTERISTICS OF THE SAFETY OF THE GENERAL-PURPOSE BUILDING NANOCEMENT, GRADE NANOCEMENT 45 C52.5

Levels of potential dangerousness of product and technology Conclusions of Federal State-Funded Health care Institution and Federal Center of Hygiene and Epidemiology of Federal Service on Customers' Rights Protection and Human Well-being Surveillance No. 16/07-4 FC of 03.10.2012)	
By product value	By technology value
Low level of potential dangerousness for consumer	Low level of potential dangerousness of nanotechnology for workers, health, population and environment

INDEPENDENT NONCOMMERCIAL ORGANISATION
"THE CENTRE OF CERTIFICATION OF PRODUCTION AND SYSTEMS OF MANAGEMENT IN THE SPHERE OF NANOINDUSTRY"

NANOCERTIFICA

CERTIFICATE OF COMPLIANCE

№ 0000050

№ РОСС RU.И750.НЖ02.000043 Validity term 10.12.2012 until 09.12.2015

OFFICE OF CERTIFICATION

OF PRODUCTS «NANOCERTIFICA» РОСС RU.И750.11НЖ02
10A, 60-year of October, Moscow, 117036, Tel./Fax: (495) 988-42-56, info@nanocertifica.ru

PRODUCTION OF NANOINDUSTRY

Nanocement of general-purpose building, grade NANOCEMENT 35 C42.5
Nanocontaining produce – category «B». Classification on the backside of the certificate
ACP Code: 573320. Serial production

MEETS THE REQUIREMENTS

TC 5733-067-66331738-2012 «Nanocement of general-purpose building. Technical conditions»

MANUFACTURER

Enclosed joint-stock company «IMETSTROY» (EJSC «IMETSTROY»)
PSRN 1027700115298, 9, 17-THE Proyezd of Mariina Roshcha, Moscow 127521

THE CERTIFICATE WAS GIVEN TO

Enclosed joint-stock company «IMET» (EJSC «IMET»)
PSRN 1105262008345, 15-5, Merzlyakovsky lane, Moscow, 121069
Tel: (495) 619-48-32, Fax: (495) 618-06-23, E-mail: moscowimet@mail.ru

ON THE BASIS OF

Of the Protocol No. 122/70 of 27.11.2012 EC «Mosstroyispytania» (РОСС RU.0001.21СЛ27).
Of the Protocol No. МС 166/1/56 (ПЭМ) of 12.10.2012 «МС ROSNANO» LLC (РОСС RU.И750.НЖ01.21ИЛ04).
Inferences of FBHO FCHaE of Rosconsumersupervision No. 16/07-4 FC of 03.10.2012 on the results of the classifying nanotechnologies and produce of nanoindustry by the degree of the potential hazard, No. 041 of 03.09.2012 by results of sanitary-epidemiological expertise by norms of radiation safety. Of the Act about results of the analysis of the state of the production No. СП-Ан-08/2012 of 04.10.2012. Of the Act of identification of produce of nanoindustry No. СП-Ан-08/2012 of 28.11.2012. Labeling

ADDITIONAL INFORMATION

Of produce by the sign of compliance is made on the basis of «Procedure of the application of the sign of compliance of the System of voluntary certification of nanoindustry produce «NANOCERTIFICA».
Scheme of certification: 3a.

STAMP MANAGER OF THE OFFICE Volkov S.Y.
Signature Surname, Initials

CATEGORIES OF PRODUCTS OF NANOINDUSTRY

Category "A" - primary nanotechnology products
Category "B" - nanocontaining products
Category "C" - services which are produced using nanotechnologies and/or nanocomponents
Category "G" - special inventory for nanoindustry

PREFERRED CHARACTERISTICS OF THE GENERAL-PURPOSE BUILDING NANOCEMENT, GRADE NANOCEMENT 35 C42.5, OBTAINED DUE TO APPLICATION OF NANO TECHNOLOGIES

Name of the parameter (exponent)		Requirements of ND (TC 5733-067-66331738-2012)	Result of the tests	Test report
Times of setting, h-min	beginning	Not less than 0-40 Not less than 2-30	2-30	No. 122/70 of 27.11.2012 EC «Mosstroyispytania» (РОСС RU.0001.21СЛ27)
	finish	Not less than 2-00 Not less than 8-00	5-40	
Limit compressive strength, MPa	2 days	Not less than 15.0	30,7	
	28 days	Not less than 42.5	61.4	

Note: Characteristics of fast-hardening nanocement 35 (clinker content 35% by mass) correspond to the class C42.5 by strength (grade 500).

CHARACTERISTICS OF NANO-SIZE STRUCTURES, INCLUDED INTO A COMPOSITION OF THE GENERAL-PURPOSE BUILDING NANOCEMENT, GRADE NANOCEMENT 35 C42.5

Name of the parameter (exponent)	Result of the tests	Test report
Presence of a nano-size polymeric shell on the surface of the particles of a cement	Thickness 15-100 nm	No. МС 166/1/56 (TEM) of 12.10.2012 «МС ROSNANO» LLC (РОСС RU.И750.НЖ01.21ИЛ04)

CHARACTERISTICS OF THE SAFETY OF THE GENERAL-PURPOSE BUILDING NANOCEMENT, GRADE NANOCEMENT 35 C42.5

Levels of potential dangerousness of product and technology Conclusions of Federal State-Funded Health care Institution and Federal Center of Hygiene and Epidemiology of Federal Service on Customers' Rights Protection and Human Well-being Surveillance No. 16/07-4 FC of 03.10.2012)	
By product value	By technology value
Low level of potential dangerousness for consumer	Low level of potential dangerousness of nanotechnology for workers, health, population and environment

INDEPENDENT NONCOMMERCIAL ORGANISATION
"THE CENTRE OF CERTIFICATION OF PRODUCTION AND SYSTEMS
OF MANAGEMENT IN THE SPHERE OF NANOINDUSTRY"

NANOCERTIFICA

CERTIFICATE OF COMPLIANCE

№ 0000050

№ РОСС RU.И750.НЖ02.000044 Validity term 10.12.2012 until 09.12.2015

OFFICE OF CERTIFICATION

OF PRODUCTS «NANOCERTIFICA» РОСС RU.И750.11НЖ02
10А, 60-year of October Av., Moscow, 117036, Tel./Fax: (495) 988-42-56, info@nanocertifica.ru

PRODUCTION OF NANOINDUSTRY

Nanocement of general-purpose building, grade NANOCEMENT 30 C32.5
Nanocontaining produce – category «B». Classification on the backside of the certificate
ACP Code: 57 3320. Serial production

MEETS THE REQUIREMENTS

ТС 5733-067-66331738-2012 «Nanocement of general-purpose building. Technical conditions

MANUFACTURER

Enclosed joint-stock company «IMETSTROY» (EJSC «IMETSTROY»)
PSRN 1027700115298,127521, 17th Maryina Roscha passage 9, Moscow

THE CERTIFICATE WAS GIVEN TO

Enclosed joint-stock company «IMET» (EJSC «IMET»)
PSRN 1105262008345,121069, Merzliakovskiy Lane 15-5, Moscow
Tel: (495) 619-48-32, Fax: (495) 618-06-23, E-mail: moscowimet@mail.ru

ON THE BASIS OF

Of the Protocol No. 123/71 of 27.11.2012 EC «Mosstroyispytania» (РОСС RU.0001.21СЛ27).
Of the Protocol No. МЦ 165/1/56 (TEM) of 12.10.2012 «MC ROSNANO» LLC (РОСС RU.И750.НЖ01.21ИЛ04).
Inferences FBHO, FCHaE Rusconsumersupervision No. 16/07-4 FC of 03.10.2012 on results of classifying nanotechnologies and produce of nanoindustry by the degree of potential hazard, No. 051 of 05.10.2012 by results of sanitary-epidemiological expertise by norms of radiation safety. Of the Act about results of the analysis of the state of the production No. СП-Ан-08/2012 of 04.10.2012.
Of the Act of identification of produce of nanoindustry No. СП-Ан-08/2012от 28.11.2012.

ADDITIONAL INFORMATION

Labeling of produce by the sign of compliance is made on the basis of «Procedure of the application of the sign of compliance of the System of voluntary certification of nanoindustry produce «NANOCERTIFICA».
Scheme of certification: 3a.

STAMP MANAGER OF THE OFFICE — Volkov S.Y.
Signature — Surname, Initials

CATEGORIES OF PRODUCTS OF NANOINDUSTRY

Category "A" - primary nanotechnology products
Category "B" - nanocontaining products
Category "C" - services which are produced using nanotechnologies and/or nanocomponents
Category "G" - special inventory for nanoindustry

PEFERRED CHARACTERISTICS OF GENERAL-PURPOSE BUILDING NANOCEMENT, NANOCEMENT 30 C 32.5, OBTAINED DUE TO APPLICATION OF NANO TECHNOLOGIES

Name of the parameter (exponent)		Requirements of ND (ТС 5733-067-66331738-2012)	Result of the tests	Tests report
Times of setting, h-min	beginning	not less than 0-40 no more than 2-30	2-15	No. 122/70 of 27.11.2012 EC «Mosstroyispytania» (РОСС RU.0001.21СЛ27)
	Finish	not less than 2-00 no more than 8-00	5-40	
Limit compressive strength, MPa	2 days	not less than 10.0	20,4	
	28 days	not less than 32.5	52.1	

Note: Characteristics of fast-hardening nanocement 30 (clinker content is 30% by mass) correspond to the class C32.5 by strength (grade 400).

CHARACTERISTICS OF NANO-SIZE STRUCTURES, INCLUDED INTO A COMPOSITION OF GENERAL-PURPOSE BUILDING NANOCEMENT, GRADE NANOCEMENT 30 C32.5

Name of the parameter (exponent)	Result of the tests	Protocol of the tests
Presence of a nano-size polymeric shell on the surface of the particles of a cement	Thickness of 14-100 nm	№ МС 165/1/56 (TEM) of 12.10.2012 «MC ROSNANO» LLC (РОСС RU.И750.НЖ01.21ИЛ04)

CHARACTERISTIS OF THE SAFETY OF GENERAL-PURPOSE BUILDING NANOCEMENT, GRADE NANOCEMENT 30 C32.5

Levels of potential dangerousness of product and technology Conclusions of Federal State-Funded Health care Institution and Federal Center of Hygiene and Epidemiology of Federal Service on Customers' Rights Protection and Human Well-being Surveillance No. 16/07-4 FC of 03.10.2012)	
By product value	By technology value
Low level of potential dangerousness for consumer	Low level of potential dangerousness of nanotechnology for workers, health, population and environment

Bickbau Marcel Yanovich —
Director General of "Moscow IMET" Public Corporation

Marcel Yanovich Bickbau — physiochemist, technologist, famous scientist in materials science, author of the first discovery in physics and chemistry of silicate that was registered in the USSR StateRegister of discoveries, #210, Doctor of Chemical Sciences, Founder and Director General of Moscow Institute of Material Sciences and Enabling Technology for 26 years, Academician of Russian Academy of Natural Sciences, New-York Academy and others.

M.Ya. Bickbau was the first who put into practice single-crystal synthesis and interpreted the atomic construction of lime silicate and other cement minerals developed the production technologies for nano-cements and alinite cements. According to his ideas, they created the new technologies of eco-friendly materials production that were based on the principles of mechanical chemistry, microencapsulation, and self-organization structure. Among them were technologies of nano-cements, high-performance concretes, super filled fireproof plastics, artificial wood without phenolic binders, shell-molding pigments, resin-bonded magnets and other materials realized in the industry of Russia, P.R. China, the UAE and special building.

The innovative approach gave M.Ya. Bickbau the opportunity to create the new prospect in the materials and components science that lays in nano-, micro- and macro- encapsulation of various dispersions for obtaining new materials and products. In particular, during the development of his ideas there was elaborated the energy saving technology of catalytic burning of cements and other fuel materials, and also the technology of mechanochemistry processing and cement nano-encapsulation that allows to reduce radically fuel production costs, to obtain high-performance and durable concretes on the base of nano-cements.

M.Ya. Bickbau was the first who elaborated the technology of granular materials (claydite gravel, chip) microencapsulation with the binder cover to get light no-fines concretes - KAPSIMET, which are widely used in buildings and roads construction; the unique energy saving equipment was created for fine crushing, mechanochemical activation and encapsulation of various materials. The new technologies were successfully realized in contraction of more than one hundred of residence, manufacturing, and public buildings in Moscow City, Moscow and Samara regions and others. Based on M.Ya. Bickbau developments, for the first time in the world practice, it was resolved the problem of recovery and neutralization of incineration toxic wastes that contain dioxins and processing into eco building products and materials. According to his project, the technology was developed on Moscow MRZ #2 under the Governmental Regulation in 2005.

M.Ya. Bickbau elaborated new architectural and building system "IMET" for the construction of multistoried and high-rise buildings with the unique complex of self-contained fire safety and evacuation; new technologies of construction of roads and railways, overpasses, bridges, engineering constructions, subway (transport system IMETSTROY) on the base of prestressed reinforced concrete slabs that are constricted in long units with steel ropes and laid over drainage concrete. According to his technologies, houses and constructions are built; different materials and fabrications are produced.

The most important M.Ya. Bickbau achievement is the creation of low-clinker nano-cements that allows to overview the development strategy of cement industry in terms of significant increase of world high-quality cements production without construction of new cement plants, only by increasing capacity of grinding sections, without working of quarries of cement raw material, fuel burning and CO2, NOx and SO2 emissions. Taking into account the new technology significance for the planet ecology, in 2012, the general committee of the Russian Academy of Natural Sciences appreciated the development of nano-encapsulation as the RF Discovery #568 and recommended the author to be awarded the Nobel Prize in Physics.

M.Ya. Bickbau is the author of more than 200 investigations, articles, and monographs. In addition, he holds more than 200 patents in the RF, the USA, P.R. China and others.