The Improvement of Foam Concrete Geoecoprotective Properties in Transport Construction

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Abstract. The article analyses 2 kinds of properties of silica sol foam concrete: technical and geoecoprotective ones. Foam concrete stabilized with silica sol foam has lower heat conductivity resulting in fuel saving. Foam concrete obtained according to sol absorption technology has lower water absorption and is good enough for blocking to prevent the environment pollution. Pollution blocking can be achieved by two methods. The first method is saturation of an article affected by oil products with silica sol. The second method is to create a special preventive protection using silica sol screen. The article shows geoecoprotective properties of protein foam soil systems.

1. Introduction
The paper suggests a new view on transport construction. The point of the view is taking into account two main properties of transport construction materials and articles at the same time. These properties are special building geoecoprotection. According to the papers [1,2,3,4,5,6] it is known that foam concrete of average density D400-D800 possesses low heat conductivity, and the wastes of foam concrete stone absorb the pollution as heavy metal ions. The idea of the paper is to decrease heat conductivity of foam concrete, to increase strength and durability of a building system, to reduce wastes. These properties are good enough for transport construction infrastructure and for the environment protection because decreased heat conductivity leads to fuel and natural resources economy; increased strength results in durability of building systems. The increase of foam concrete wastes absorption contributes to purification of the environment from heavy metal ions. Silica sol is one of inorganic sols used for foam stabilization and for sol absorption technology. Table1 presents inorganic soles.

Table 1. Mineral systems as sols

Mineral system as nanosolution	name of sol	name of technology
$SiO_2 \cdot nH_2O$	Silica sol	soling or foam soling
$xAl_2O_3 \cdot ySiO_2 \cdot nH_2O$	alumina silica sol	soling
$x^1CaO \cdot xAl_2O_3 \cdot ySiO_2 \cdot nH_2O$	Ca-alumina silica sol	soling

n, x, y, x^1 - coefficients in formulas

2. Methods and results

For the experiment silica sol was chosen as the purest for lithosphere. Table 2 presents a thermodynamic calculation with Ca (II) – ions of artificial stone on cement base.

Table 2. Thermodynamic calculation of sol processes

Examples of reactions	ΔG^0_{298} of the reaction
1. $6Ca^{2+}+6(SIO_2 \cdot H_2O) +12OH^- = 6CaO \cdot 6SiO_2 \cdot H_2O+11H_2O$	-740,89
2. $Ca^{2+}+2(SiO_2 \cdot H_2O)+2OH^-= CaO \cdot 2SiO_2 \cdot 2H_2O+H_2O$	-201,65
3. $6Ca^{2+}+3(2SiO_2 \cdot 3H_2O)+12OH^-= 6CaO \cdot 6SiO_2 \cdot H_2O+14H_2O$	-284,89
4. $Ca^{2+}+2SiO_2 \cdot 3H_2O+2OH^-= CaO \cdot 2SiO_2 \cdot 2H_2O+2H_2O$	-50,65

The result of Table 2 is possibilities and chemical activities of silica sol in cement stone as inorganic sols. For the experiment silica sol was chosen (Table 1), 3% concentration of nanosize particles and pH of nanosolution with the value 10. Two technologies of the use of foam concrete formation with silica sol were chosen. The first technology is obtaining stabilized foam by using silica sol and the second is sol absorption technology (SAT). Both of them are connected with technical properties of foam system. Geoecoprotective properties were examined as ability to absorb water and oil products from an article saturated with silica sol, Table 3 and Table 4.

Table 3. Properties of foam concrete D500 with silica sol

Composition of mix per $1m^3$ foam concrete mix				Properties of foam concrete*					
				control samples			samples with sol		
cement, kg 370	filler, kg 100	water, liters 183	foam formation with silica sol, liters 1,98	compressive strength, MPa/%	bending strength, MPa/%	heat conductivity λ BT/m.^{0}	compressive strength, MPa/%	bending strength, MPa/%	heat conductivity λ BT/m.^{0} C/%
				Method 1. Silica sol stabilized foam					
				1,3/100	0,69/100	0,12/100	1,9/146	1,9/146	0,10/80
				Method 2. Method SAT (sol absorption technology)					
				1.12/100	0.73/100	0.12/100	1.63/153	1.19/150	0.12/100

*Properties were obtained after 28 days of natural hardening t~20-22^0 C, research properties were done according to general documents in Russia for foam concrete.

Table 4. Water absorption of foam concrete D500

Water absorption, %		
Control articles	Articles with sol stabilized foam	Articles according to sol absorption method
100%	20% decrease	more than 60% decrease

3. Discussion

In Table 3 and 4 one can see that the main difference between articles is in two properties – heat conductivity and water absorption. For this reason, both methods are good enough for geoecoprotection – sol stabilized foam for fuel economy because of lower heat conductivity. The articles obtained according to SAT can be stable and, as a result, more durable in the environment. The last property is connected with waste obtaining, and the more durability there is, the less the waste level is. But that is not all. It was suggested [7, 8, 9, 10, 11] that geoecoprotective foam concrete articles affected by oil products should be blocked using silica sol absorption technology. The first method is the following: after being saturated with oil, foam concrete article was saturated with silica sol and later was taken for water analysis. Oil products decreased for more than 90% in the water with sol-blocked samples compared to non-blocked samples. The second method is obtaining preventive foam concrete screen to protect soil from oil leakage. This screen must be more reliable if saturate one side of the screen with silica sol and create a protective film preventing leakage through the screen into the soil during exploitation. These geoecoprotective properties are examined in papers [12-20].

But not only foam concrete articles have geoecoprotective properties. There are problems of soil strengthening and detoxication and there are complexes in soil technologies differ by agent performance: mixing or injection. There are 2 other very good properties of foam systems. We deal only with protein foam complexes with heavy metal ions; for foam of any other nature this property is impossible.

The first property is high flow of foam cement (foam concrete) and the second is stable condition within nearly 2 hours for stabilized protein foam using silica sol. High flow of foam system makes it possible to use injection methods or watering using irrigation; stabilized foam can be distributed on the soil surface. Two foam properties: flow and distribution, - can be useful for strengthening and detoxication due to hardening processes of foam concrete cement, detoxication properties of calcium silicate, calcium silicate hydrates and possibilities of protein complex with heavy metal ion formations. Table 5 shows methods of aeration in transport construction systems.

Table 5. Soil aeration in transport systems using protein foam

Active foam systems	Object of influence	Properties of influence	Possible mechanism of influence	Method of foam system use
Protein foam with silica sol	Powder (railway embankment sand or dust during transportation)	1. Raising dust 2. Protection from heavy metal ions.	1.Formation of the geoecoprotective membrane on the soil surface 2. Formation of heavy metal ion complex with foam protein	Foam distribution on the soil surface
Foam cement, foam concrete with protein stabilized foam	Soil, emptiness	Detoxication of the system and strengthening at the same time	Geoecoprotection due to formation of heavy metal complex with foam protein	Injection in the soil

Stabilized protein foam with silica sol can form a membrane to prevent dust from being raised during transportation or any other problems like that. The membrane cannot only prevent dust from being raised, for example railway embankment with powder sand, but it also prevents from heavy metal ion pollutions thanks to protein complex. So aerating using foam concrete is good enough for strengthening and detoxication. The influence of silica sol can be well explained taking into consideration papers [21-25].

4. Conclusions
1. Properties of foam concrete with silica sol of two methods are shown.
2. Foam concrete with sol stabilized foam has 20% decrease in heat conductivity.
3. Foam concrete with sol absorption technology has more than 60% decrease of water absorbtion, blocks oil products and prevents soil from pollution.

References
[1] Svatovskaya L B, Shershneva M V and Puzanova Y E 2010 *Geochemistry International* **T 48 6** pp 621-623
[2] Svatovskaya L, Shershneva M, Baydarashvily M, Sychova A, Sychov M and Gravit M 2015 *Procedia Engineering* **117** pp 350-354
[3] Svatovskaya L B, Sakharova A S, Baidarashvili M M and Petriaev A V 2015 *IACMAG 2014* pp 152
[4] Svatovskaya L B, Sychova A, Sychov M and Okrepilov V 2016 *MATEC Web of Conferences* 53 01024 pp 1-4
[5] Svatovskaya L B, Sychova A, Sychov M and Okrepilov V 2016 *MATEC Web of Conferences* 53 01024 DOI: **10/105**
[6] Svatovskaya L B, Sychova A, Sychov M and Gravit M 2016 *Procedia Engineering* **165** pp 1771-1775
[7] Svatovskaya L B, Sychova A, Soloviova V, Maslennikiva L and Sychov M 2016 *Indian Journal of Science and Technology* **vol 9(42)** n 104304
[8] Svatovskaya L B, Sychova A, Soloviova V, Maslennikiva L and Sychov M 2016 *Indian Journal of Science and Technolog*y November 2016 n 104231 **vol 9 (42)**
[9] Sakharova A S, Svatovskaya L B, Baidarashvili M M and Petriaev A V 2016 *Procedia Engineering* The 3rd International Conference on Transportation Geotechnics ICTG 2016 pp 1401-1408
[10] Svatovskaya L B 2016 *Natural and thechnical sciences* ISSN 1684-2626 **9** pp 49-52
[11] Svatovskaya L B and others 2016 *Transport construction* **7** pp 30-32
[12] Svatovskaya L B and others 2016 *Monogragh* PGUPS
[13] Cheremisina O A, Sychev M M, Myakin S V, Korsakov V G, Popov V V and Artsutanov N Y 2002 *Russian Journal of Physical Chemistry* **76 (9)** pp 1472-1475
[14] Myakin S V, Korsakov V G, Panova T I, Sosnov E A, Fomchenkova Yu C, Sychov M M and Shilova O A 2011 *Glass Physics and Chemistry* **37 (6)** pp 624-628
[15] Korsakov G, Alekseev S A, Sychov M M, Tsvetkova M N, Komarov E V, Lee B Myakin S V and Vasil'eva I V 2007 *Thermodynamic Model Russian Journal of Applied Chemistry* **80 (11)** pp 1931-1935
[16] Sychov M M, Mjakin S V, Nakanishi Y, Korsakov VG, Vasiljeva I V, Bakhmetjev V V, Solovjeva OV and Komarov E V 2005 *Cl phosphors Appl Surf Sc.* **244 (1-4)** pp 461-464
[17] Sychov M M, Zakharova N V and Mjakin S V 2013 *Ceramics International* **39** pp 6821-6826
[18] Bakhmet'ev V V, Sychev M M and Korsakov V G 2010 *Russian Journal of Applied Chemistiy* **v 83** JSyl 1 pp 1903-1910
[19] Sychov M, Nakanishi Y, Kominami H, Hatanaka Y and Hara K 2008 *Eu Thin Film Phosphor Jap. J of Appl Phys* **Vol 47(9)** pp 7206-7210
[20] Sychov M, Nakanishi Y, Vasina E, Eruzin A, Mjakin S, Khamova T, Shilova O and Mimura H 2015 *Chem Letters* **Vol 44(2)** doi: 10.1246/cl 140926
[21] Scrivener K L and Kirkpatrick R J 2008 *Cement and Concrete Research* **38** pp 128-136

[22] Cement Association of Canada 2006 *Concrete Design Handbook* **3rd** edition pp 983
[23] RILEM TC 197 CNM 2002 *Nanotechnology in Construction Materials*
[24] ACI 236-0D 2007 *Material Science – Nanotechnology of Concrete*
[25] Raki L, Beaudoin J J and Alizadeh R 2009 *Nanotechnology in Construction Proceedings of NICOM3 3rd International Symposium on Nanotechnology in Construction 2009* pp 119-124