Lithosynthesis of the properties in the transport construction on the cement base

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Abstract. Lithosynthesis is the new method of technical and geocoprotective properties improvement for the cement based construction. The point of the method is the reactions in the pores and capillaries of artificial mineral stone. The classification of the reactions is presented and level of the properties improvement is shown. The examples of the lithosynthesis application are shown with geoecoprotective aspect taken into consideration.

1. Introduction
There are a few ways to influence the concrete on the cement base technical properties. Now a new one based on the pore and capillary properties of artificial stone on the binder base is offered. The point of the method is penetration of absorbed solution with ions or nanoparticulars in the structure of the hardening artificial stone on the cement base or any other mineral nature. The size of the pores and capillaries must be more than 1 nm. Such kind of pores and capillaries can absorb not only ions but nanoparticulars with size from 1 nm and then in the stone a reaction between substances is possible. The result of interaction is calcium silicate hydrate formation if we use silica sol or heavy metal ions silicate hydrates if we use heavy metal ion solution for the detoxication, for example the waste water. According to the papers [1-6] it is possible to detoxicate heavy metal ions in such a way.

2. Methods and experiments
In the Table 1 the lithosynthesis classification of the reactions according to the nature solution are shown – nano solution and solution with heavy metal ions. In the Table 2 the thermodynamic aspect of the lithosynthesis reaction is shown and according to the conclusions of the thermodynamic every reaction has negative free Gibbs energy and because of that they are allowed. To improve quality of concrete on the cement base it is necessary to use hardening concrete of 2-3days from the start of the hardening. The concrete any class articles were sunk into the solution of the 3% silica sol concentration for the saturation (a few hours). After that concrete had a usual process of the normal (natural) hardening and in 28 days it was checked according to the usual method of Russian state standards.
Table 1. Classification of lithosynthesis according to nature of constructions

| Nature of absorbing construction | Examples of solutions | Process of binding (fragment of reaction) | Free Gibbs energy of the reactions | Main property of influence |
|---------------------------------|-----------------------|------------------------------------------|----------------------------------|---------------------------|
| Silicate Hydrates, pH>7         | 1. Silica sol         | 1. SiO$_2$·nH$_2$O, soling               | N/A                              | Technical, detoxication   |
|                                 | 2. Al(III) – solution | 2. Al$^{3+}$+6OH$^-$=[AlO$_3$]$^{3-}$   |                                  |                           |
|                                 | 3. Fe(III) - solution | 3. Fe$^{3+}$+3OH$^-$=Fe(OH)$_3$          |                                  |                           |
|                                 | 4. Pb(II), Cu(II), Cd(II) and others | 4. Pb$^{2+}$+2OH$^-$=Pb(OH)$_2$   |                                  |                           |
|                                 | heavy metal ions      | contained solutions                      |                                  |                           |
|                                 |                       |                                          |                                  |                           |
|                                 |                       |                                          |                                  |                           |
| Silicate Hydrates, pH>7         | 5. Organic solution   | 5. 2C$_6$H$_5$OH+Ca(OH)$_2$ = Ca(C$_6$H$_5$O)$_2$+2H$_2$O | Negative                         | Detoxication              |
|                                 |                       |                                          |                                  |                           |
| Sulfate Hydrates pH=7           | 6. Pb(II)-solution    | 6. Pb$^{2+}$+CaSO$_4$·2H$_2$O = PbSO$_4$↓+ Ca$^{2+}$+2H$_2$O | Negative                         | Detoxication              |
| Aluminates Hydrates pH>7        | 7. Silica sol         | 7. Soling                                | Negative                         | Technical                 |
|                                 |                       |                                          |                                  |                           |

Table 2. Thermodynamic calculation of the reactions during lithosynthesis*

| n/n  | Reaction during lithosynthesis | $\Delta G^{0}_{298}$ of the reactions, kJ |
|------|-------------------------------|-----------------------------------------|
| 1.   | 6Ca$^{2+}$+6(SiO$_2$·H$_2$O)+12OH$^-$=6CaO·6SiO$_2$·H$_2$O+11H$_2$O | -417.4                                 |
| 2.   | Ca$^{2+}$+2(SiO$_2$·H$_2$O)+2OH$^-$=CaO·2SiO$_2$·2H$_2$O+H$_2$O | -93.4                                  |
| 3.   | 6Ca$^{2+}$+3(2SiO$_2$·3H$_2$O)+12OH$^-$= 6CaO·6SiO$_2$·H$_2$O+14H$_2$O | -367.8                                 |
| 4.   | Ca$^{2+}$+2SiO$_2$·3H$_2$O+2OH$^-$=CaO·2SiO$_2$·2H$_2$O+2H$_2$O | -177.2                                 |
| 5.   | 2Pb$^{2+}$+2(CaO·SiO$_2$·H$_2$O)+H$_2$O=PbO·SiO$_2$·H$_2$O+Pb(OH)$_2$+SiO$_2$·H$_2$O+2Ca$^{2+}$ | $\Delta G^{0}_{298}$<0         |
| 6.   | 2Cd$^{2+}$+2(CaO·SiO$_2$·H$_2$O)+H$_2$O=CaO·SiO$_2$·H$_2$O+Ca(OH)$_2$+SiO$_2$·H$_2$O+2Cd$^{2+}$ | $\Delta G^{0}_{298}$<0        |

* In the reactions 1-4 silica sol is used for technical properties increasing. The reactions 5, 6 are the examples of heavy metal ions detoxication.

In the Table 3 are shown the main properties of SAT (sol absorption technology) concrete.

The transport concrete can be utilized in the geosphere when we have waste water with heavy metal ions. The absorption of heavy metal polluted solution takes place and hydroxides and heavy metal ion silicate hydrates are formed in the concrete body. In the Table 4 the results are shown as detoxication of heavy metal ions in numbers of TC (tolerable concentration). For the experiment the dispersions of any class crushed concrete were used. If the construction articles are taken, then the numbers of TC may be a little lower.
### Table 3. Results of SAT-concrete

| Concrete classes | Compressive strength, +Δ | Bending strength, +Δ | Water absorption, -Δ | Abrasion, -Δ | Cold resistance cycles, +Δ, |
|------------------|--------------------------|----------------------|----------------------|--------------|-----------------------------|
| B15, B20, B25, B30 | 15-30                    | 20-35                | 50-65                | 20-30        | 75-90                       |

### Table 4. Detoxication coefficient of construction material as property due to lithosynthesis, number

| Construction material | Average absorption capacity, c, kg/t | Cu(II) 3·10⁻³, kg/t | Pb(II) 32·10⁻³, kg/t | Cd(II) 0.5·10⁻³, kg/t |
|-----------------------|-------------------------------------|---------------------|----------------------|----------------------|
| Cement and clinker minerals | 3-4 | 1000-1300                    | ~100                | ~6000                |
| Foam article          | ~2  | ~800                          | ~70                 | ~4000                |
| Heavy concrete        | ~1  | ~300                          | ~30                 | ~2000                |

*Numbers of TC are ratio absorption capacity, C, at tolerable concentration, TC

### 3. Discussing

The special part of SAT is using hardening articles and such kind of method can be useful for transport technology when surface is especially important. As an example might be taken a road exploitation when surface of concrete carries extremely high loads (more than 50 million during life cycle). The hardness of concrete SAT surface of road has been checked and the result is the prediction of life cycles more than 40% increasing. In the papers [7, 8, 9, 10, 11] is shown the mechanism of the properties increasing. As for the detoxication, the meaning of the detoxication coefficient is high enough.

It is known [12, 13, 14, 15, 16] that not far from railway has been observed pollutions nearly 20 number of TC and articles or dispersions of materials due to lithosynthesis can detoxicate of heavy metal ions. To develop lithosynthesis for geosphere detoxication has been obtained number TC for materials, for example, calcium sulphates till 100 meaning. It is clear that these are large possibilities for lithosynthesis application and according to the papers [17, 18, 19, 20, 21] details of possible influence may be explained.

It is important to say that technologies on the cement base have the very reserve for lithosynthesis. For example, the technologies of soil strengthening by means of mixing with cement. Then the artificial stone is formed with pores and capillaries, and because of that the lithosynthesis is good enough for the detoxication of waste water with heavy metal ions, when strengthened soil absorbs such kind of waste water.

In the table 5 are presented the examples of usage the lithosynthesis of the construction systems properties.
Table 5. Lithosynthesis of the construction properties

| Construction system | The way of taking in the system | Lithoreaction | Properties |
|---------------------|---------------------------------|--------------|------------|
| I Articles and constructions on the cement base | Absorption of silica sol, solution, pH > 7 | Hydrates calcium silicates formation, $\Delta G^{0}_{298} < 0$ | Technical Increasing the level of the properties, quality and durability | Geocoprotective Waste decreasing, because of durability, decreasing of natural resources consumption Detoxication of heavy metal ions because of binding in substances with very low solubility product |
| II Articles and constructions on the cement base | Absorption of heavy metal ions containing in solution (waste water) | Hydrates of heavy metal ions, silicates hydroxides, $\Delta G^{0}_{298} < 0$ | Not less than before of absorption |
| III Strengthened soils due to cement | Absorption of waste water with pollution | Formation of hydrates and hydroxides of heavy metal | Not less than before of absorption Detoxication |

4. Conclusions.
1. Lithosynthesis for the cement properties improvement and detoxication is shown.
2. The levels of technical properties improvement by means of lithosynthesis are being shown.
3. The level of detoxication due to lithosynthesis is shown.

5. References
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