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ORIGINAL PAPER

## PHYSICAL-CHEMICAL PRINCIPLES OF CLAY MODIFYING INTO FILLER, POZZOLANIZATION THROUGH REHYDRO-LIMING, FOR CEMENT CONCRETE RESISTANCE TO THE NATURAL DISASTERS

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ARTICLE INFO	ABSTRACT							
Article history:	The aim of this paper is to increase the stability of buildings and structures to natural disasters by							
Received 23 July 2021 Accepted 21 September 2021	modifying the Georgian clays into cement concrete filler by creation-using of rehydro-liming pozzolanization technology.							
Available online 4 October 2021	The risk of damage-destruction of buildings and structures caused by earthquakes, sea storms, floods, mudflows, has increased in the world.							
Keywords:	Risks can be prevented by increasing of building and structure stability by reducing the anisotrop							
Georgian clay Rehydro-liming pozzolanization technology Cement concrete filler	<ul> <li>dehydrating preserving habitus, are modified into a void containing (mAl<sub>2</sub>O<sub>3</sub>·nSiO<sub>2</sub>) base minerals in which, after mixing in cement concrete while rehydro-liming, Ca(OH)<sub>2</sub> is sorbed. The tobermorite, stratlingite, generated in filler, together with cement ettringite form fiber-needle-flaky habit clusters by modifying the structure of cement concrete with 3D self-nano-reinforcement, by reducing the anisotropy of strength – by increasing of stability to loads with variable direction-magnitude.</li> <li>It has been proven that in order to prevent risks of catastrophe, it is possible to use modification of Georgian clays by thermal dehydration in cement concrete technologies, which will create the preconditions for cement concrete pozzolanization by rehydro-liming, so the study of the basics of this process is actual.</li> </ul>							

#### INTRODUCTION

The topic of the paper is the study of physicalchemical basics of modification of Georgian clays as an active filler-addition and its pozzolanization, and the aim is to enhance the stability of cement concrete and buildings and structures to the loads with variable magnitude and direction caused by natural disasters (earthquake, storm, mudflow, flood), i.e. to prevent the risk of disasters.

Based on the topic and purpose of the paper, Gardabani clay was selected as the object of research.

**Disaster risk.** Most of the buildings and structures in Georgia were built with cement concrete of anisotropic strength and unstable to loads with variable direction and magnitude in 1960-80, when the seismic resistance norm was 7. Currently the norm is 8, but they are still built with cement concrete of the same properties, which helps to maintain the risk, which is unacceptable under the 'National Strategy for Disaster Risk Reduction in Georgia'.

The purpose of seismic construction is structure to 'follow the seismic vibration'- which according to BS EN 1998-1 and EN 1998 reduces the damage. Earthquake damage to buildings are prevented in Japan making structure lightweight using the fiberglass materials. In Georgia the so-called 'Colchian Ode' is made of fibrous material - wood. The 'ode' is installed on wooden/stone (seismic) piles. The 'Ode' is swinging during the earthquake - it is seismically resistant, which is confirmed by Skhvitaridze et al. (2017). Disaster-resistant cement concrete is unknown in technology and on the market today. The technology is to be created, but survives the structures from the time of the Roman Empire, as well as brick buildings of VI-XI centuries in Georgia, which withstood earthquakes and other natural disasters. They contain calcium hydrosilicate stratlingite 2CaO·Al<sub>2</sub>O<sub>3</sub>·SiO<sub>2</sub>·8H<sub>2</sub>O (C<sub>2</sub>ASH<sub>8</sub> Cement chemist notation - CCN), whose habitus is flaky, which presumably makes nano-reinforcement and increase resistance to seismic oscillation.

Disaster resistance includes: resistance of cement concrete and buildings and structures to variable direction oscillation-bending, loads of lateral share character and point-impact-ware influence, which is confirmed by Skhvitaridze et al. (2015), together with Stark et al. (2001). The compressive strength of cement concrete is almost 10 times higher than the

Cite this article as: Skhvitaridze R, Shapakidze E, Gejadze I, Abazadze M et al: Physical-chemical principles of clay modifying into filler, pozzolanization through rehydro-liming, for cement concrete resistance to the natural disasters. Acta Geodyn. Geomater., 18, No. 4 (204), 503–510, 2021. DOI: 10.13168/AGG.2021.0036 bending strength  $R_C/R_b > 10$ , and 20 times higher than tensile -  $R_c/R_t > 20$ . It is an anisotropy of strength. The mineral portlandite Ca(OH)<sub>2</sub> (CH in CCN notation) is responsible for it, which is formed in cement from cement minerals. The strength of aggregates in cement-concrete is on average 6-7 on the Mohs scale, of the cement stone -4-5, and of Ca(OH)<sub>2</sub> -2-3. Cement-concrete collapses at the cement/filler boundary during bending loads, because the weakest compound Ca(OH)<sub>2</sub> is accumulated there, as confirmed by Stark et al. (2001). In addition, during sulphate corrosion of  $Ca(OH)_2$  by the action of  $SO_4^{2-1}$ penetrated from the outside into the cement concrete, late but inevitably reducing the bending and compression strength of structure, it forms the expansive mineral ettringite  $C_3AC_3\overline{S}H_{32}$  (CCN) with fiber-needle-flaky habitus.

$$Ca^{2+} + SO_4^{2-} + 2H_2O \rightarrow CaSO_4 \cdot 2H_2O;$$
(1)

$$3CaSO_4 + 3CaO \cdot Al_2O_3 + 32H_2O \rightarrow$$
  
$$3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 32 H_2O \{C_3AC_3\overline{S}H_{32} (CCN)\}$$
  
(2)

In the 21<sup>th</sup> century increasing of market demand and structure stability and prevention of cement concrete anisotropy is realized by: metal reinforcement – macro reinforcement, as well as by fibers – volume 'dispersed 3D micro reinforcement'.

In the 21<sup>th</sup> century, in some countries, in order of cement economy and intensification of cement concrete hardening process started mixing of highly active filler metakaolin - Al2O3·2SiO2 obtained by thermal treatment of kaolin clay, in the cement composition, as Kakali et al. 2001, as well as Kovo 2011), as well Mansour et al. (2012), confirmed. The basis for the use of metakaolin in cement-concrete is the property of mineral kaolinite Al<sub>2</sub>O<sub>3</sub>·2SiO<sub>2</sub>·2H<sub>2</sub>O: in result of heating above 550°C the kaolinite structure dehydrates and at 700 °C irreversibly forms the mineral metakaolin Al<sub>2</sub>O<sub>3</sub>·2SiO<sub>2</sub> which according to Tailor H.F.W., acting with Ca(OH)<sub>2</sub> of cement concrete causes pozzolanization, i.e. a reaction of binding to SiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub>. Calcium hydro silicate CaO·SiO<sub>2</sub>·H<sub>2</sub>O (CCN) and calcium hvdro aluminosilicate stratlingite C2ASH8 (CCN) are formed in cement concrete.

Scientific novelty of the research is: the initial hypothesis formed based on Roman/Georgian construction traditions, as well as using the analysis of references: cement concrete strength anisotropy and building and structure instability can be prevented by: dehydration maintaining of habit of the main constituent mineral of aqueous aluminosilicate rock (e.g. clay); mixing of obtained modifiers in cement concrete; pozzolznization with rehydro-liming with portlandite Ca(OH)<sub>2</sub>; 3D nano-reinforcement of the interfacial transition zone in cement concrete – with an increase in bending strength.

In particular, kaolinite of clays (or other aqueous aluminosilicate minerals: glauconite, mica, amphibolite etc.) by dehydration at 700 °C

temperature maintaining the mineral habit is modified into metakaolin  $Al_2O_3$ ·2SiO<sub>2</sub> (or other mineral containing ...mAl<sub>2</sub>O<sub>3</sub>·nSiO<sub>2</sub>... base), containing voids released from water. After mixing in cement concrete, in voids of mineral modifiers, instead of H<sub>2</sub>O, rehydration of Ca(OH)<sub>2</sub> unit occurs. This procedure we call rehydro-liming [Note: Rehydration is the replenishment of the space (created after dehydration) with water or electrolyte. Ca(OH)<sub>2</sub> is an electrolyte, hence: the replenishment of the space (created after dehydration) by the electrolyte Ca(OH)<sub>2</sub> is "Rehydro liming"].

Then pozzolanization will occur with the formation of clusters of tobermorite  $5CaO \cdot 6SiO_2 \cdot 9H_2O$  or  $C_5S_6H_9$  (CCN) and stratlingite  $C_3AC_3\overline{S}H_{32}$  (CCN) having flaky habit, increasing the bending strength with 3D nano-reinforcement of the interfacial transition zone. This hypothesis is schematically presented as shown in Figure 1.

It is known that mixing natural pozzolan material (tuff, pumice etc.) in cement causes pozzolanization of cement (Srinivasu et al., 2014), increase in activity and brand strength, which according to Stark et al. (2001), is intensified by heat treatment of pozzolanic material together with cement before grinding at 600-700 °C. The information sources do not discuss the issues of differences in the ongoing pozzolanization processes after mixing of metakaolin (or similarly heat-treated pozzolanic material) and natural pozzolan in cement and their effect on the anisotropy of cement concrete strength that are to be studied.

Kaolin clays for making metakaolin are practically non-existent in Georgia, but there are many other clays from which the technology of making a product similar to metakaolin is unknown, so the topic, purpose and object selection of the present paper, validation of scientific novelty is new and relevant today.

#### MATERIALS AND METHODS

There were investigated clay rocks:  $\mathbb{N} = a - from$ the banks of the river Duruji (near the city of Kvareli),  $\mathbb{N} = b - from$  Teleti (near the city of Tbilisi) and three types of low-melting clays -  $\mathbb{N} = c$ - from the village of Metekhi,  $\mathbb{N} = d - village$  Miriani and  $\mathbb{N} = - from$  the city of Gardabani.

Clay research methods include preparation of materials by drying at room temperature and shredding within 30-100 mc. Chemical analysis of clays was carried out in accordance with GOST 21216-2014 (Clay raw materials. Test methods). Results of chemical analyses are given in the Table 1. The mineral composition of clays was determined using an Optica B-383POL polarizing microscope. X- ray phase analysis was carried out on a Dron-4.0 diffractometer, NPP 'Burevestnik', with a copper anode and nickel filter. U (voltage kV) -35 kV. Ι (current mA) – 20mA. Shooting speed -2 degrees, /min.  $\lambda$ =1,54178 Å. For thermogravimetric analysis (DTG) a NETZSCH derivatograph with analyzer STA-2500 REGULUS an



Fig. 1 Representation of nanoprocess occurring in the simplest two-layer package of kaolinite structure, included in Gardabani clay.

N⁰	LOI	SiO <sub>2</sub>	TiO <sub>2</sub>	$Al_2O_3$	$Fe_2O_3$	FeO	$Mn_2O_3$	CaO	MgO	$SO_3$	Na <sub>2</sub> O	K <sub>2</sub> O
а	4.50	59.95	0.89	17.30	3.45	3.65	0.59	1.53	2.43	0.30	2.20	2.20
b	7.01	47.19	-	15.90	13.36	-	0.10	6.30	4.10	1.39	2.86	1.30
c	13.70	49.35	0.24	11.20	4.55	-	0.24	13.55	2.28	0.55	1.13	1.73
d	15.16	46.71	0.42	13.20	4.19	-	0.10	15.5	1.40	0.73	1.34	1.05
e	10.60	52.84	-	15.07	6.47	-	-	7.06	2.49	1.36	1.19	2.17

Table 1 The chemical composition of clayey rocks, mass %.

thermogravimetric and differential thermal analyzer (TG/DTA) was used. The sample was heated to 1000 °C in a ceramic crucible, heating rate 10 deg/min. Standard  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>.

# **RESULTS AND DISCUSSION**

### CLAYS

In the initial stage of studies, the probability of expected transformations in clay-water – 700 °C temperature modification of clays and in cement-water-25 °C temperature of mixing was predetermined by thermodynamic calculations using a method developed by Babushkin V.I., Matveev G.M., Mchedlov-Petrosian O.P.

Framework and water are in equilibrium in aqueous aluminosilicate minerals containing in structure of natural clay. Under ambient conditions of 25 °C (298 °K) it is thermodynamically impossible to remove structural water from clay.

When heated to 700 °C temperature kaolinite is dehydrated – metakaolin is obtained.

$$Al_{2}O_{3} \cdot 2SiO_{2} \cdot 2H_{2}O \rightarrow (700) \ ^{\circ}C \rightarrow$$
$$\rightarrow Al_{2}O_{3} \cdot 2SiO_{2} + 2H_{2}O \ (gas)$$
$$\Delta G^{^{\circ}}_{973} = -3,20 \ \text{kJ/mol}; \tag{4}$$

If we mix water with metakaolin at 25 °C, incomplete 'rehydration' will occur.

 $Al_2O_3 \cdot 2SiO_2 + 2H_2O \text{ (liquid)} \rightarrow (25 \text{ °C}) \rightarrow$ 

 $\rightarrow$ Al<sub>2</sub>O<sub>3</sub> ·2SiO<sub>2</sub> ·2H<sub>2</sub>O  $\Delta$ G<sup>0</sup><sub>298</sub> = - 148.91 kJ/mol; (5)

If metakaolin is mixed with Ca(OH)<sub>2</sub>, at 25 °C, according to Taylor, 1990, pozzolanization occurs

forming calcium silicate hydrates having fibrous, needlelike or flaky habit: 1.4 nm tobermorite  $C_5S_6H_9$  (CCN), as well as stratlingite generating  $C_2ASH_8$  (CCN) which is confirmed thermodynamically by the method elaborated by Babushkin et al. (1986).

According to our initial hypothesis, the pozzolanization of metakaolin begins with its 'rehydration' with 'lime water' - Ca(OH)<sub>2</sub>, 'or rehydro-liming', during which water 'returns' to the voids formed during rehydration with lime units. So, if the natural clay after dehydration under 700 °C during 1 h, is mixed with Ca(OH)2 at 25 °C temperature, the rehydro-liming of the metakaolin formed in clay occurs and subsequently 'pozzolanization' reaction takes place, forming tobermorite and stratlingite.

$$6 (Al_2O_3 \cdot 2SiO_2) + 17 Ca(OH)_2 + 40 H_2O (liquid) \rightarrow$$
  

$$\rightarrow (25 ^{\circ}C) \rightarrow$$
  

$$\rightarrow 5CaO \cdot 6SiO_2 \cdot 9H_2O + 6(2CaO \cdot Al_2O_3 \cdot SiO_2 \cdot 8H_2O)$$
  

$$\rightarrow C^{\circ} = -120 7^{\circ} hV_{2} + 120 CaO \cdot Al_2O_3 \cdot SiO_2 \cdot 8H_2O (AO)$$

 $\Delta G^{\circ}_{298} = -120.78 \text{ kJ/mol.} \tag{6}$  If Ca(OH)<sub>2</sub> is mixed with natural clay at 25 °C,

due to the presence of kaolinite instead of metakaolin in the clay, no 'rehydration' will occur, and 'pozzolanization' will occur weakly, as evidenced by the low  $\Delta G^{\circ}_{298}$  reaction potential.

$$\begin{array}{l} 2(\text{Al}_2\text{O}_3\cdot2\text{SiO}_2\cdot2\text{H}_2\text{O}) + 7\text{ Ca}(\text{OH})_2 + 8\text{ H}_2\text{O} \rightarrow (25\ ^\circ\text{C}) \rightarrow \\ \rightarrow 2(2\text{CaO}\cdot\text{Al}_2\text{O}_3\cdot\text{SiO}_2\cdot8\text{H}_2\text{O}) + 5\text{CaO}\cdot6\text{SiO}_2\cdot9\text{H}_2\text{O} \\ \Delta \text{ G}^\circ_{298} = -45.02\ \text{kJ/mol} \end{array}$$
(7)

According to the results of microscopic analysis, the structure of clay rocks is as follows:



Fig. 2 X-ray diffraction patterns of clays: a – Duruji, b – Teleti, c – Metekhi, d – Miriani, e – Gardabani.

a - a structure with weakly pronounced shale elements. With multiple magnification, it can be seen that the main components of the structure are chlorite and hydromica minerals, iron hydroxides and organic compounds. The coarse fraction is represented by minerals of quartz-feldspar composition.

b - Mineralogy is represented mainly by quartz, plagioclase, calcite, glauconite, in small amounts pyroxene and biotite. Most of them are quartz-feldspar minerals.

c - The clay is highly carbonized, the integrity of the structure is broken. Most of the residual structure consists of pelitic carbonate-mica rocks, partly of the minerals of quartz and feldspar.

d - The clay is carbonized, the integrity of the structure is broken. The main residual structure is made up of pelitic carbonate minerals and an insignificant partminerals of quartz, feldspar, smectite, chlorite.

e - The clay has been charred and the integrity of the structure has been compromised. Most of the residual structure consists of pelitic carbonate-mica minerals, partly quartz, feldspar, amphibole, smectite, chlorite, as well as particles of grains and fragments of pyroxene. Iron oxides and ore minerals are found in single grains of amphibole and pyroxene.

The results of the X-ray phase analysis are shown in Figure 2.

The X-ray diffraction patterns of the studied clays show the presence of clay minerals (14.96, 14.65, 7.55, 7.14, 7,10, 4.53, 4.46, 4.25, 3.85, 3.74,

3.66, 2.86, 2.27, 2.12, 1.98, 1.87, 1.81) Å; quartz (3.34 Å); felspars (3.85 Å), carbonate (3.02 Å).

To determine the temperature range in which the clay transforms into a modified form, DTG was carried out, the curves of which are shown in Figure 3.

According to DTG data, the endothermic effect at 100-150 °C is present on all curves, which corresponds to the removal of physically bound water. In the temperature range 650-850 °C, an endothermic effect is observed, which is obviously associated with the dehydration of the crystal lattice of clay minerals and their transition to an amorphous form – metakaolin. The peak of this endothermic effect at a relatively low temperature (718 °C) is observed in Gardabani clay, which indicates a high tendency to temperature activation – modification, and therefore all our further studies were carried out only on Gardabani clay.

To determine the temperature changes in the mineral composition, Gardabani clay was heated in a laboratory muffle furnace at temperature 550, 600, 700 and 800 °C with a holding time of 1 hour. Calcined samples were subjected to X-ray phase analysis. The x-ray diffraction patterns (Fig. 4) clearly show the phase changes of the clay with an increase in the firing temperature. On the diffractogram a (original clay) the clay mineral chlorite is presented (14.65, 7.55, 4.46, 3.74) Å. With an increase in the firing temperature (b, c, d, e), the amount of chlorite decreases and X-ray amorphous phase appears (in the form of bulge).



Fig. 3 Clay DTG curves: a – Duruji, b – Teleti, c – Metekhi, d –Miriani, e – Gardabani.

It is obvious that during the heat treatment of clay rocks from 550 °C, dehydration of clay minerals begins and metakaolin appears, i.e. fired clay acquires pozzolanic properties to bind  $Ca(OH)_2$  into calcium silicate hydrates.

The ability to bind Ca(OH)<sub>2</sub>, i.e. the determination of the pozzolanic activity of the modified additives was carried out according to GOST R 56593-2015 by the absorption of Ca(OH)<sub>2</sub> from its aqueous solution, recalculated into CaO (Fig. 5).

The additive is considered highly active when the amount of CaO absorbed exceeds 70 mg/g, moderately active when the amount of CaO absorbed is in the range of 30-70 mg/g, and considered low active when less than 30 mg/g of CaO is absorbed.

Gardabani clay heat treated at different temperatures, showed the best absorption of CaO from the lime solution at all stages of the test (Fig. 5e). The reactivity of heat treated clayey rocks to Ca(OH)<sub>2</sub> is explained by the fact that at 600-800 °C the kaolinite mineral  $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$  – is dehydrated and transformed into an active anhydride – metakaolin ( $Al_2O_3 \cdot 2SiO_2$ ).

Based on the results of this study, it is possible to determine promising local rocks, which, when developing a temperature modification regime in order to increase pozzolanic activity, are able to significantly reduce the proportion of clinker in the composition of Portland cement and the proportion of the cement in the composition of cement concrete, without reducing mechanical strength. Such a rock is, Gardabani clay – heat treated at 700 °C.

#### **CEMENTS AND CEMENT CONCRETES**

Cements were prepared by grinding (residue on sieve N 008 5 %) in a laboratory mill with addition of modified clay rocks with different heat treatment temperatures and different amounts of additives. The constant parameter for all tested cements was the heat treatment time of the additives –1 hour. For comparison according to BS EN 197-1:2011, a control test was prepared – no additive (Fig. 6). The compressive strength of cement was determined according to the method of the European standard DIN EN 196-1 and flexural strength of concrete samples was determined according to BS EN 206: 2013+AI:2016. Cement and cement-concrete test specimens were solidified in special chambers at 25 °C.

The highest strength was shown by cements with the addition of 10 % and 20 % modified Gardabani clay. With an increase in temperature to 800 °C the strength of cements decreases slightly. Obviously, the hydraulic activity of cements is affected by the content in the mineral additive of components, capable of undergoing structural changes during heat treatment, leading to the formation of active compounds that contribute to an increase in cement mechanical strength. The hydraulic activity of the cement is also influenced by the structure of the added mineral additive.

Tests were carried out with the addition of diatomite for comparison.

The diatomite highly active absorbent of CaO (300 mg/g CaO) containing up to 95 % amorphous



Fig. 4 X-ray diffraction patterns of Gardabani clay: a – original, b - fired at 550 °C, c - fired at 600 °C, d - fired at 700 °C, e - fired at 800 °C.



Fig. 5 Kinetics of CaO absorption by heat-treated clays from a saturated solution: a – Duruji, b – Teleti, c – Metekhi, d – Miriani, e – Gardabani.



Fig. 6 Hydraulic activity of cement samples after 28 days hardening containing different amounts of additives, with different modifications of temperature with exposure for 1 hour.



Fig. 7 Change in 28-day strength CEM I 42,5 after adding diatomite and dehydrated Gardabani clay.

SiO<sub>2</sub>, according to Taylor, 1990, drastically reduces the mechanical strength of cement. In our test, mixing 20 % diatomite with CEM I 42,5 type cement reduces its 28-day strength by 20 %, and mixing of 20 % dehydrated (modified) Gardabani clay increases the strength by 15 % (Fig. 7).

This is because the interaction of diatomite amorphous  $SiO_2$  with CaO produces only the mineral tobermorite:

$$5Ca(OH)_2 + 6SiO_2 + 4H_2O \rightarrow 5CaO \cdot 6SiO_2 \cdot 9H_2O$$
  

$$[C_5S_6H_9 (CCN)] \tag{6}$$

When the cement is mixed with the additive containing the mineral metakaolin XAP  $Al_2O_3$ ·2SiO<sub>2</sub>, like the (6) reaction, the mineral stratlingite  $C_2ASH_8$  is formed together with the tobermorite  $C_5S_6H_9$ . For the testing the mechanical strength on bending of CEM I 42,5 type and CEM I 42,5+20 % modified Gardabani clay type cements (cement consumption in concrete recipe = 450 kg/m<sup>3</sup>), there were made 15x15x60 cm prisms of B 40 class concrete and tested after hardening in water for 28 days. The test showed that the addition of thermally modified Gardabani clay

filler - increases the bending strength of cementconcrete (Fig. 8), thereby reducing anisotropy and increasing the stability of buildings and structures. Habitus of minerals included in the mineral additive also effects the strength of cement concrete. The cement concretes with fiber-needle-flaky habitus mineral additives achieve high strength. The filler additive increases the cement concrete strength to bending loads, i. e. imparts the property of stability to natural disasters. This is due to the fact that in cement concretes, the addition of metakaolin AS<sub>2</sub> (CCN) promotes the formation of new phases of hydration products. Its active silica reacts with Ca(OH)<sub>2</sub>, forming calcium hydrosilicate - tobermorite C<sub>5</sub>S<sub>6</sub>H<sub>9</sub> and active hydroaluminosilicate - the mineral stratlingite C<sub>2</sub>ASH<sub>8</sub> – which is confirmed by Tailor, 1990.

#### CONCLUSION

Studies have shown that Gardabani clay after 700 °C thermal dehydration acquires the ability of rehydro-liming and pozzolation of cement concrete and can be used to reduce the share of the most energy-intensive and expensive component in cement –



Fig. 8 Change in 28 day bending strength of B 40 concrete prisms after adding dehydrated Gardabani clay.

clinker, and to reduce the proportion of cement in cement concrete without reducing mechanical strength. Hypothesis confirmed: Aluminosilicate aqueous minerals of clays by dehydration up to 700 °C temperature, maintaining the habitus, modified as metakaolin, or other mAl<sub>2</sub>O<sub>3</sub>·nSiO<sub>2</sub> based mineral, containing the voids emptied of water, in which, after mixing in cement concrete, instead of H2O the Ca(OH)<sub>2</sub> is rehydrated, and this is the process which there we 'rehydro-liming'. Then call is pozzolanization, forming in cement concrete structure first clusters of tobermorite C<sub>5</sub>S<sub>6</sub>H<sub>9</sub> having the layered habitus and stratlingite C<sub>2</sub>ASH<sub>8</sub> with early ettringite  $C_3AC_3\overline{S}H_{32}$  with an increase of bending strength. Primary clusters will be grown as hybrid clusters of cement aluminosilicate type compounds AS - C<sub>5</sub>S<sub>6</sub>H<sub>9</sub>, AS - C<sub>2</sub>ASH<sub>8</sub>, braided to each other in Afm and FAft phases. Volumetric 3D nano reinforcement of the cement-filler interfacial transition zone and the entire structure will realize with increasing of strength and stability.

Created opportunities to enhance cement concrete and building-structure stability to loads of variable direction-magnitude caused by natural disasters (earthquakes, storms, mudflows, floods), i. e. opportunity of catastrophe risk prevention. The scientific value of the obtained results is to determine the physical-chemical essence of the technology of synthesis of building materials from clay, which is based on the management of crystal development by the method of thermal modification.

The product of the research\_is the technology of cement concrete of less anisotropic strength and stable to natural disasters using the management of clay properties by their modification and structure 3D nano reinforcement. With the knowledge gained from research, it is possible to increase the stability of cement concrete buildings and structures.

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