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MODERN VIEWS ON THE CREATION OF EFFECTIVE COMPOSITES

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Abstract.

Taking into account the huge volumes of building and structures construction made of concrete and reinforced concrete, the task of their repair becomes one of the most important problems requiring an urgent solution, the development of new materials and effective technological approaches. Only the right choice of means and methods of repair work performance may provide a long-term positive effect during the subsequent operation of a structure.

Nowadays, the use of dry construction compounds altered significantly the specificity of repair construction works, showed their high efficiency and benefits in comparison with traditional construction compounds.

The fundamental basis for the development of materials for various purposes is a physical-chemical approach to the understanding of structural and associative properties of microscopic formations: compounds, molecules, atoms, and even the knowledge of microstructure is not enough to predict the end microscopic properties of a created system. In order to evaluate the characteristics of the material the whole complex of interactions is taken into account as for its individual components, so as for structural organizations.

Keywords: dry construction compounds, layered composites, contact zones, the affinity of structures, micro- and macrostructure, durability.

Introduction. There are often the problems in practice with the creation of contact layers for various composite materials, including repair ones. During the construction and repair of any building or structure the creation of

structure element joints takes place, which may be presented either by masonry made of different materials (natural stone or by tiles, ceramic and silicate brick, various blocks of expanded clay concrete, heavy or porous concrete, etc.) and the use of special mortars prepared from different raw materials; the carrying out large panel, large-block and monolithic buildings and structure mounting, the implementation of outdoor decoration of buildings, the creation of protective materials and coatings, etc. In order to carry out the abovementioned works, it is necessary to create a solid, reliable intermediate layer of a compound, bonding different materials, providing a protective coating and the durability of a structure as a whole. Special problems arise during the creation of solutions on the joints of several different materials, especially if a structure works in extreme conditions [1-4].

Main part.

Nowadays, there is a number of provisions concerning the formation of a strong reliable durable material, individual perceptions and the ways of implementation concerning the creation of modern composites in accordance with the required physical, mechanical and performance properties.

We proposed a unified approach to solve this problem. Thus, the hypothesis was put forward about the necessary target formation with the desired composite properties, about the making of connections between various components of raw materials that compose this composite material or a contact layer between different materials. And here it is advisable to use the "experience" of geological processes [3-5]. The thing is about the genesis of a wide range of anisotropic rocks (banded, schistose and other structures), in which the anisotropy ratio can be reduced to 2 ... 3, in contrast to the 5 ... 7 and among more layered structures produced by a man.

In order to create a durable and reliable contact between the structural elements it is necessary to create a stable internal connection, designed to provide a specific physical-mechanical and operational requirements of a structure as a whole. This contact zone should have the similarity, i.e. the proximity according to basic properties and the affinity of genetic origin with the material matrix. This affinity requires the creation of such a structure that would ensure a relative position and a corresponding relation of components and ultimately guaranteed the cooperative work of this contact zone with the elements of two, and may be several related materials.

Considering the essence of building composite affinity, we mean the concepts and the properties of element chemical affinity, as speaking of building materials, we take into account first of all the chemical composition of the constituent elements from which these materials are created.

In our opinion, the affinity of structures in building material science is appropriate to apply to characterize two or several individual materials to interact with each other and the characteristics of their stability degree and resulting

contact layer. The affinity of structures can be assessed by various parameters of strength, density, porosity, etc. An equation can be developed expressing quantitatively and qualitatively the dependence of these values on the characteristics of contacting interacting materials and the dependence of qualitative indicators for contacting materials according to Gibbs Law.

In our opinion, the main criterion for the evaluation of affinity quality characteristics is a contact layer strength and durability. During the creation of a material taking into account the affinity of structures it is necessary to consider the structural features of the material during its installation in the structure as well as at its further use.

Currently, the structure of building materials structure is studied at three levels: at macro, micro and nanolevel. Under a structure, or an internal structure of building materials, as well as other physical bodies, we mean the spatial arrangement of particles with different dispersion which are in stable mutual relations (primary or secondary ones) with a order of adhesion between them. Besides, the term structure includes the size and the location of pores, capillaries, section surfaces, microcracks, and other elements. In our opinion, due to the set of new tasks before the material scientists in modern conditions and due to the need of new efficient material creation the material structure analysis requires new attitudes and approaches, especially during the creation of thin layers of materials, widely required at the moment. During the creation of such materials there is the issue about the structure of material surface and inner layers as they work in a very specific environment.

The structure of a surface layer for artificial construction materials differs generally from the inner layers according to several reasons: the atoms and molecules located on the outer surface of the material part have an excess energy as compared to the particles located within the material; Besides, the surface layer of the material being in an actual contact with the environment, experiences environmental influences all the time, both during manufacture and during use. The excess energy of a surface layer is caused by the fact that each particle on the surface of a solid body and liquid has uncompensated chemical bonds which form an asymmetric force field on a surface. This force field draws surface particles into the material, creating a compressive stress on a surface.

Thus, a surface layer is constantly in an elastically stressed state, and its particles have a significantly larger reserve of potential energy than the particles of an inner layer. Consequently, the particles of a surface layer are more responsive to the environment and are entered into chemical reactions more actively. The energy value of a surface layer is directly proportional to the chemical bond energy of this material and depends on environmental parameters. Thus, for example, the surface energy of a solid body at the boundary with the liquid that wets it, is reduced by the amount equal to the strength of surface particle interaction with liquid. Admixtures, the wetting of a surface with

active liquids, diffusion processes make a significant influence on the structure of surface and internal material layers. Impurities make different effects on the properties of the outer and inner layers. If the admixtures have a lower surface energy than the material they are distributed evenly over the surface, reducing its energy; If a surface energy is greater, they are concentrated on some areas of a surface or are moved into the inner layers of the material, where they may provide both positive and negative effects on its properties. Wetting is important during the development of artificial composite materials and it is necessary to reduce the energy of solid element surfaces, which allows to obtain denser packages of particles in produced materials. Diffusion is a spontaneous movement of matter particles, which resulted in an equilibrium distribution of these particles concentration in the volume of gas, liquid and a solid body. The macrostructure of a building material inner layer is easily visible on a split by an ordinary magnifying glass. The composition of the structure includes separate grains of different size, pores and the matrix, combining these grains in a single conglomerate. A cement stone, aluminosilicate glass, clay, calcite, the quartz of different crystallinity, etc. may serve as a matrix.

The division of the building material structure into the macro and microstructure is highly conditional and has a purely methodological significance; it allows to simplify the rheological models of system deformation characterized by different sizes of components, and therefore to apply simpler mathematical models for process description.

If we consider a contact zone creation for two different materials from the theoretical positions of accumulated and existing knowledge on this issue, it is necessary to consider the basic properties of each material, and genetic characteristics of their macro-, micro- and nanostructure, the required physical-mechanical and operational characteristics, the purpose and the conditions of this structure service. And all these properties and requirements need to be combined into a single unit.

The law of structure affinity in building material science designed and proposed by us is based on fundamental properties and regularities inherent in the main base and fastening material and the necessary set of properties that provide guaranteed properties to the contact layer for a reliable and a durable operation of a structure.

First of all, in order to create a reliable and durable contact layer between the main and auxiliary materials, for example, between some wall materials and a plaster solution, you need to take into account the chemical affinity of applied materials, their compatibility, their preconditions for a reliable contact creation, the absence of antagonistic reasons between them. These conditions are especially relevant for the creation of contact layers during repair work performance. The performance of all these conditions will provide a guaranteed long service life of this contact layer, the reliability and the safety of a structure as a whole. It is necessary to take into account that we have complex

structures quite often, which may consist of numerous chemical elements, but, nevertheless, their compatibility, incompatibility, and may be synergistic effects shall be taken into account.

A significant impact on the creation of a contact layer is performed by the genetic characteristics of the main and auxiliary materials, as well as the raw materials of a contact layer; in this regard, it is necessary consider and select raw materials based on their genesis. Thus, the reactivity of the system components can be regulated taking into account the set tasks.

In order to create a reliable contact layer the structure of the main (basic) and finishing materials is of great importance. This structure in its turn, has their own characteristics of macro-, micro- and nanostructures. The problem of a stable contact layer creation is the formation of such a structure that it will sprout in the contact structures and will create a single monolithic layer and will form a structure to ensure sustainable mutual relations with a particular coupling order between them. The concept of a structure includes the size and location of pores, capillaries, phase separation surfaces and microcracks. These structure elements play the most important role in the development of a strong stable structure for a contact layer.

The affinity according to phase compositions is of great importance concerning the main and auxiliary materials and a contact zone and the phase transitions of water located in their pores, which makes the most significant impact on all material properties and behavior under operational loads.

The affinity of the main (basic) and finishing layer and their contact zone must meet a number of physical properties, including the average densities, porosity, hydrophysical and thermophysical properties. The creation of a rational contact zone, taking into account these properties will provide a high and reliable performance characteristics of the composite.

The creation of a reliable contact zone between the main and finishing materials ensures a high affinity according to mechanical properties. At the performance of these conditions, a high strength and the reliability of created material joints can be achieved, however, it should be borne in mind that when you create contact zones one should strictly follow the guidelines on the performance of construction works.

For example, in order to create the reliable contact layers between the bases of two fundamentally different materials presented by ceramic and silicate bricks and applied finishing layers of mortar based on a cement binder it is necessary to know the genesis and the chemical composition of these bases materials. So, clay characterized by the content of the following basic oxides is the main structure-forming substance for ceramic brick that creates micro- and macrostructure during firing: SiO_2 - 40 ... 70%, Al_2O_3 - 15 ... 35%, K_2O and Na_2O - 1 ... 15%, Fe_2O_3 - 0 ... 7%.

The result of firing and melt solidification is the microconglomerate formed in which crystal grains of mullite (various modifications of silica and other substances) are crystallized during cooling and cemented by the amorphous mass of solidified melt, the latter borders the individual grains of a filler and is located in the intergranular voids.

Unlike ceramic brick, sand-lime brick is a cementless artificial material obtained by the compression of a moistened lime and quartz sand mixture with subsequent hydrothermal synthesis (in the environment of saturated water steam by the pressure of 0.8 ... 1.3 MPa and the temperature of 175 ... 200 °C), and the obtaining of various calcium hydrosilicates depending on the composition of the initial mixture: tobermorite $5CaO{\cdot}6SiO_2{\cdot}5H_2O$, weakly crystallized calcium hydrosilicates: (0,8-1,5) $CaO{\cdot}SiO_2{\cdot}H_2O$ and (1,5-2,0) $CaO{\cdot}SiO_2{\cdot}H_2O$. In the mixtures with high lime content hillebrandite $2CaO{\cdot}SiO_2{\cdot}H_2O$ is synthesized.

Thus, in these systems, the basic materials for the application of a mixed finishing layer are presented by cementless conglomerates, obtained after calcination and hydrothermal treatment and, of course, they have a various mineral and chemical compositions, as well as specific, inherent genesis predetermining the creation of different conditions for the formation of a contact layer structure. Due to the different origin the formation of macro-, micro- and nanostructures in ceramic and silicate bricks takes place at various stages of processing according to their technological features and has its own specific features.

An important factor during the formation of a contact layers is a base condition. One should take into account the feature of a base material surface layer to create the initial structures for a future contact since a surface layer structure is formed depending on the state of a surface. This structure is created by atoms and molecules located on the outer surface of a base material. A surface layer has an excess energy as compared to the inner layers of the base material and reacts with the environment and enters into chemical reactions more actively.

In order to ensure a reliable contact zone of considered material junctions by physical and mechanical properties it is necessary to analyze according to each factor in detail and take the best decisions according to the conditions and the peculiarities of their functioning. A particular attention should be given to affinity features by phase content of contacts and phase transitions of water in these areas, since this factor largely determines the operating conditions of the whole constructive solution.

After the combining of all these elements we suggested the law of structure affinity in material science to create robust and reliable contact zones on the borders of different materials.

One of the brightest and the most demonstrative examples of structure affinity in material science is the ancient building sites: a mortar with the main block material the oldest building of the planet - the Egyptian pyramids, the

affinity of mortar and natural stone material, still working Greek and Roman waterworks and aqueducts. The affinity of a contact zone on the border of natural stones and slabs, from which the pyramids and aqueducts were built, ensured the longevity of the structures for tens of centuries. This contact zone developed from the dispersed phase of sandstone contributed to the creation of a dense coating to prevent age-old rather severe climate impacts on the structure elements.

It is known that every law reflects objectively the necessary link existing between some phenomena, a sustainable relationship between phenomena, existing internal relationship between causes and an effect of some phenomenon or a material object.

The law of structure affinity in building material science is intended to reflect the existing internal relations and the developed ones as the result of directed structures at the targeted development of new composites, which should provide the necessary conditions for a safe operation functional operation of building products and structures. The law of affinity between structures is a complex system consisting of subsystems or components, each of which performs its functions. The elements of the system are not isolated from each other, and are grouped so as to ensure the appropriateness of the entire system. Any changes in a particular element or the substitution of one element to another usually leads to the change of properties within the entire system. The law of structure affinity in building materials is based on fundamental properties and regularities inherent to the main base and fastening material and the necessary set of properties which provide guaranteed properties to a contact layer for reliable and durable operation of a structure. The Elements of the system are interconnected and the more versatile communications, the more effective the created system.

Considering the practical implementation of the proposed affinity law among structures in building material science, one may provide a series of examples for the creation of targeted structures in respect of building composites for various purposes.

The studies conducted by the authors with regard to the principles of affinity law among structures, proved the possibility of directed change in respect of capillary-porous structure and moisture transfer control in lime and cement stone during the combined use of superplasticizer additives and mineral fillers with a specific granulometry which allows you to design the composites based on binders for the restoration of ancient monuments. This technique was tested during the restoration of Tsaritsyno and Rostov Veliky ensembles, architectural, historical and cultural facilities in Siberia and Bulgaria.

The use of affinity law among structures allowed to create a new effective thermal insulation, structural silicate material on the basis of active granular fillers with consistently high thermal insulation properties with an improved adhesion strength with masonry mortars, which is especially important in seismic dangerous regions and to establish a mechanism for a contact zone development of a granular filler with a silicate matrix during an autoclave processing. The established patterns of a structure change and physical-mechanical properties of silicate products allowed to develop volumetric contact areas between a filler and a matrix. The creation, or the introduction of the most effective closed pores in their structure in terms of thermal insulation may significantly reduce the thermal conductivity, increase the thermal resistance of building walls, to reduce the weight of wall structures and to improve the adhesion to masonry mortars [6,7].

Taking into account the law of structure affinity structures the efficient thermal insulation compounds were designed on the basis of dry construction mixes, effectively working on different grounds: on heavy and light concretes, on ceramic and silicate bricks [8]. It was found that the thermal insulation solutions applied to different bases have different adhesion to bases. Thus, heavy and lightweight concrete and ceramic bricks have approximately the same adhesion value and silicate brick has the adhesion value above 50% due to the affinity of silicate brick minerals and thermal insulation solution.

Nowadays the obtaining of highly effective building materials of a new generation is accompanied by the use of complex component composition from chemical and mineral perspective in order to obtain high quality building materials of different functionality with improved, and sometimes with radically new properties and a certain predetermined structure. Such binding creation is based on the principle of targeted technology control during its all phases: the use of active components, the development of optimal compositions, the use of chemical modifiers, the use of mechanical-chemical activation of components and some other methods.

The implementation of geonics provisions [9] in the construction material science contribute to the creation of new high-strength, "smart" composites with predetermined properties.

Summary.

The implementation of affinity laws among structures involves the creation of a hardening composite system, which have the foundations of responding to the changing conditions of synthesis and operation; New formations are synthesized purposefully and nano-, micro- and macrostructure is created with the ability of defect autohealing occurring in a certain range of operating loads [10-15]. The theoretical and practical approaches should be the prerequisite for the creation of a new class of "smart" construction materials with some effective properties [16-32].

Thus, certain requirements exist during the creation and the use of any building material. The violation of these requirements results in the reduction of strength, in non-compliance with operational requirements, and sometimes even in the destruction of a structure, and the violation of affinity laws among structures leads to the above stated consequences.

Conclusions.

The proposed theoretical approaches to the development of affinity law among structures could serve as a serious scientific base for the further development of modern building material science to create low power, environmentally sound, competitive at the domestic and foreign markets, high-performance materials with improved properties and a predetermined structure.

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