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Anisotropy of Materials Properties of Natural and Man-Triggered Origin

Anna Aleksandrovna Kuprina, Valery Stanislavovich Lesovik,
Liliya Hasanovna Zagorodnyk and Michail Yuryevich Elistratkin
Belgorod State Technological University, Street 46,
Kostyukova, 308012 Belgorod, Russia

Abstract: We illustrate the similarities of the structure, texture, nature of artificial materials and rocks destruction. It is considered that some anisotropic rocks have anisotropy coefficient value lower than that of the masonry. The use of new designing methods of masonry mortars compositions based on Geonics theses the provisions and structures affinity principles will create high-layered systems which is especially important for construction in earthquake-prone areas.

Key words: Anisotropy geonic principles, rock, the principle of structures affinity, masonry, mortars

INTRODUCTION

Today individual construction is growing rapidly. Official data of SA Supervision states that accidents in comparison with the average of previous years (1983-1993) have increased by 41% (Blockley, 1981; Matousek, 1981). Accidents are connected with large deviations from the strength characteristics of materials unfavorable due to the high heterogeneity of material properties (Lesovik, 1994).

Blocks and bricks are the main structural materials, providing the human environment. However with the improvement of the geometry, the surface of the wall material the necessity in a new approach to the design of masonry mortars compositions has arisen. The task is to form a unified composite material having a high adhesion of the individual layers to each other. Analysis of the effects of earthquakes (Orlovich and Derkach, 2011) shows that the destruction of masonry structures occurs mostly on the border wall material seam which is characterized by poor adhesion of cement sand mortar to the base and there is need to work towards the formation of lasting contact layer of masonry elements.

MATERIALS AND METHODS

In accordance with SNIP II-22 81 adhesion strength depends on the type, material of masonry element and strength of mortar but according to the requirements of Eurocode 6 the type of used mortar and material of component influence the adhesion strength. Adhesion strength is a multifactor parameter, its value is affected by:

- The adsorption properties of the stone
- Condition of the wall material surface (open porosity, its structure, etc.)
- Type of used wall material
- Degree of workability of the mortar (mobility, consistency)
- Water-holding capacity
- Uniformity of mortar mass (Orlovich and Derkach, 2011)

Today in order to achieve the objectives it is necessary to develop a new research direction in cybernetics, i.e., Geonics which will enter a new design stage, manufacture and operation of the material. Formation of multilayer system structures (masonry) based on geonic principles will create materials with a wide range of properties and great potential of endurance (Lesovik, 2012a, b).

We would like to note that human activity connected with the production of building materials and constructions remained geological processes on the formation of the structure of rocks (Fig. 1).

After stratified layered strata have an important property which was formulated in the form of the law by Nicolaus Steno in 1669 where it is said: “Every upper layer is deposited only after the lower layer was deposited”. There existed a break between deposits of the first and the second layers (Tevelev, 2011). This law is valid in the erection of masonry too which confirms the concept of coping geological processes in the formation of artificial structures. It says about the application of geonic principles when designing building structures (Lesovik, 2012a).

Corresponding Author: Anna Aleksandrovna Kuprina, Belgorod State Technological University, Street 46, Kostyukova, 308012 Belgorod, Russia

Fig. 1: Artificial material and its natural analogue: a) the crack of pushing in a layered sandstone filled with feldspar and b) old masonry (Germany)

Masonry is a complex composite anisotropic material with its heterogeneous structure at all hierarchical levels of the systems (from macro to submicro) where "wall material" is a large filler (Belentsov, 2008). Masonry is a heterogeneous material, laced with pores and voids (from the gel to capillary), cracks of various nature, voids, formed in the result on recrystallization of neoplasms (micro level), unevenness of putting masonry material (macro level). This system of discontinuities and inhomogeneities leads to the fact that under the load change in the structure is accompanied with the development or appearance of cracks of different levels (micro, meso, macro-cracks). Let's consider the masonry as a composite material. As it is described in many works, the division of the structure into blocks occurs before the load is applied which is connected with the different coefficients of volume deformation of solution component and mortar masonry material (macro-level of system) at the micro level the cracks appeared in the result of volume changes of the matrix material on the surface with the filler. The appearance of dislocations in the matrix at different hierarchical levels leads to the fact that high strength characteristics of large filler cannot be implemented. Strength of the masonry is only 10-15 % of the strength of the wall material but the strength of the concrete reaches about 80 Mpa at potentially possible strength 600-800 MPa (strength of ettringite and GSK).

Loosened structure of solids is the main cause of the anisotropy of their properties. The review of works on the strength of the rocks and artificial conglomerates shows that one of the features of non-continuous bodies is relatively low tensile strength compared to the compressive strength. Complexity of the of artificial conglomerates structure leads to the fact that the morphological characteristics at the atomic or molecular levels of the components of cement stone cannot raise the real strength up to of theoretical one and increase the ratio R_{flex}/R_{coMP} to one (Orechov and Zertsalov, 1999). Cracks choose tortuous path chosen due to weak links between blocks or grains.

Therefore, extensive way of strength development and deformation properties of masonry exhausted itself because increase in the strength characteristics of wall material a mortar has a little effect on the strength of masonry in general. Masonry consists of stones or blocks on 80-85% but the mortar is a weak link in the masonry.

Masonry will be considered "Ideal" when we get closer to the strength of the main elements of masonry wall unit (Belentsov, 2008). The presence of weak links between the blocks is one of the main reasons for differences in the theoretical and real strength of the solid. Break of the weak links between the grains and blocks explains the mechanism of destruction of the tear inhomogeneous material (artificial and natural solids) and determines low tensile strength compared to compressive strength R_{flex}/R_{coMP} = 0.05-0.10 (Orechov and Zertsalov, 1999).

The similarity of the formation mechanism and destruction of various real solids influenced joint discussion of the strength problem of genetically different materials. The main property is fracturing which unites rocks and artificial materials.

Structural and textural features of rocks contribute to the development of the anisotropy of their physical and mechanical properties (Fig. 2).

The presence of weak links between the blocks is one of the main reasons for differences in the theoretical and real strength of the solid. Destruction of both geological layers and massive engineering structures is in the result of alternating process of continuous accumulation of cracks or damages in the system. Process of the accumulation of cracks corresponds to the hierarchical pattern of crack development process in accordance with the main feature of large-scale structures heterogeneity properties.

Masonry corresponds to 5 layered structure of strength from mega to nano level (Fig. 3).

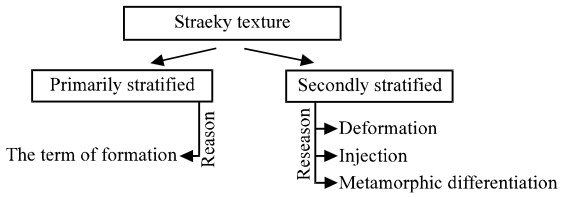

Fig. 2: Terms of creating anisotropy of physical and mechanical properties of rocks

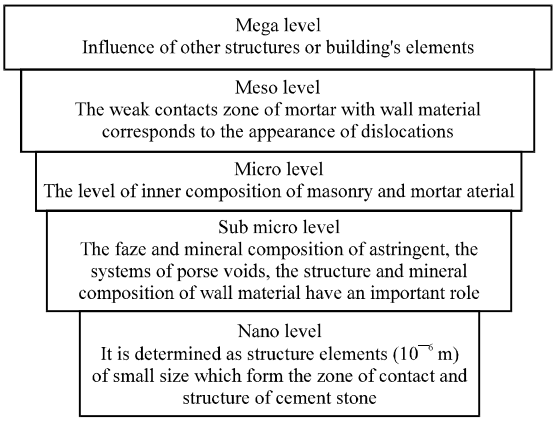

Fig. 3: Hierarchical system of intermittent and continuous cracks in the material

Most of the rules for the design of stone masonry and reinforced masonry structures is considered as an isotropic material, so the deformation characteristics of masonry are set only in the direction perpendicular to the horizontal mortar seams. Currently, intensive work is being done abroad in the direction of research of masonry because of its anisotropy and work in conditions of plane stress strain state (Kubica, 2011).

In order to determine the strength characteristics of the brickwork samples with the anisotropy of its properties, the compressive force was applied along and across the horizontal mortar seams (Fig. 4).

Tests were being performed in accordance with the procedure set in EN 1052-1. For the preparation of masonry mortars the dry mortar mixture M200 of prefabrication was used. Compressive strength of the mortar was adjusted in accordance with the procedure set in GOST 5802-86 and EN 1015-11. Tested masonry samples were made with mortar of a compressive strength 10.7 MPa and the thickness of the seam was 10 mm. There were two series masonry sample tested the (1 series with 4 samples at compression across and along the horizontal mortar seams). Masonry samples were being made of homogeneous ceramic brick of M200.

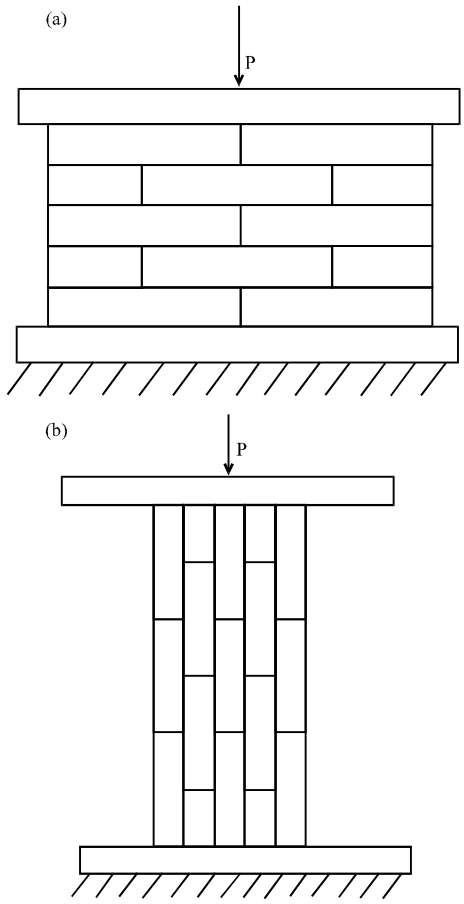

Fig. 4: Scheme of testing masonry samples by compressive load: a) perpendicular to the horizontal mortar seams and b) parallel to horizontal mortar seams

The results of experimental research of masonry anisotropy properties are shown in Table 1.

Anisotropy ratio of anisotropic rocks is also high under the absence of affinity of different strips of rocks structures. Thus, for the mica slates, consisting of alternating strips enriched with mica a high coefficient of anisotropy expressed in the sharp difference between strength parameters in determining the last stratification across and along is characterized (Kanis = 1.8). In the rocks layers which are stacked by close in chemical and mineralogical composition and structure of the layers, the anisotropy ratio is in the range from 1.1-1.15 (granites, quartz sandstones). For the first time, on the base of the affinity structures principle, in the study (Lesovik and Chulkova, 2011) the possibility to control the structure formation processes as well as the controlled formation of capillary porous structure in mineral systems has been proved. In this connection understanding and disclosing

Table 1: Results of masonry tests

Strength of brick (MPa)	Masonry mortar strength (MPa)	Compressive strength of masonry (Mpa)		S_m (MPa)	υ_{var} (%)	$K_{anis} = R_{compr}x / R_{compr}y$
		$R_{compr}x$ (MPa)	$R_{compr}y$ (Mpa)			
Compression across the horizontal mortar seams (Mpa)						
18.9	10.7	6.6	-	0.49	6.7	1.7
Compression along the horizontal mortar seams (Mpa)						
18.9	10.7	-	3.9	0.24	4.8	-

physical and chemical phenomena and processes which underlie in the base of forming multi-layer materials structure and artificial conglomerates becomes more urgent. Understanding these processes will allow controlling the processes of structure formation using technological methods.

RESULTS

The process of forming of the structural links of contact layers depend on the specific and total surface energy of mineral particles of mortar filler which are the main characteristic of forming mortar and masonry strength. The smaller the total surface of filler mineral particles, is less the structural strength of the mortar. On hardening it happens spatial displacement of particles with forming hardening mass structure according to the principle of chemical affinity, i.e., those particles are closing each other first which have the specific values of free surface energies equal or close on value.

There is the reserve for increasing the structural strength of the growth of the specific surface of the system solid phase and it is considered as a consequence of a greater number of contacts between particles accretion masonry mortar and wall material. This is achieved in two ways: mechanical (grinding), chemical (supplementation). Increase of solid phase distribution homogeneity in the material volume and creation of a closer packing of the particles are the main factors of optimization of such multilayer systems as masonry, namely, creating defect-free zone of contact, increasing the strength characteristics, durability. As the astringent of mortar it is advisable to apply the substances having a high chemical affinity with the material masonry.

CONCLUSION

Thus the texture similarity, the nature of artificial materials and rocks destruction explain the availability of getting masonry strength close to their natural analogs on strength, namely, new approaches to the design of masonry structures based on the roles of Geonics allow creating high-strength materials with an ordered structure. Chemical and mineral masonry and plaster mortars affinity to the masonry materials (ceramic, sand-lime bricks, CSC, cellular concrete) will provide a reliable and durable adhesive cohesive contact of multilayer structures elements.

REFERENCES

Belentsov, Y.A., 2008. The directed formation of a contact zone in the system of frame-matrix of anisotropic composite materials. Bull. BSTU, 4: 37-42.

Blockley, D.I., 1981. Reliability Theory-Incorporating Gross Errors. In: Structural Safety and Reliability: Proceedings of Icossar 81, the 3rd International Conference on Structural Safety and Reliability, the Norwegian Institute of Technology, Trondheim, Norway, June 23-25, 1981, Moan, T. and M. Shinozuka (Eds.). Elsevier, Amsterdam, The Netherlands, UK., ISBN-13: 9780444419941, pp: 259-282.

Lesovik, V.S. and I.L. Chulkova, 2011. Management of Structurization of Construction Composites Siberian Road-Transport Institute Press, Omsk, Russia, Pages: 462.

Lesovik, V.S., 1994. Genetic basis of energy saving in industry of building materials. Building, 7: 96-100.

Lesovik, V.S., 2012a. Geoniks: Subject and Objectives. BSTU Press, Belgorod, Russia, Pages: 213.

Lesovik, V.S., 2012b. Lowering energy intensity of producing the building materials, by using geological and technogenetics energy processes. Proceedings of the 18th International Conference Building Material, (BM'12), Weimar, Ibaus, pp: 239-252.

Matousek, M., 1981. A system for a Detailed Analysis of Structural Failures. In: Proceedings of Icossar 81, the 3rd International Conference on Structural Safety and Reliability, the Norwegian Institute of Technology, Trondheim, Norway, June 23-25, 1981, Moan, T. and M. Shinozuka (Eds.). Elsevier, Amsterdam, The Netherlands, UK., ISBN-13: 9780444419941, pp: 535-544.

Orechov, V.G. and M. Zertsalov, 1999. Fracture Mechanics of Engineering Structures and Rocks. American Concrete Institute, Michigan, USA., Pages: 327.

Orlovich, R.B. and V.N. Derkach, 2011. Strength evaluation of masonry mortars by inspection of stone buildings. J. Civil Eng., 7: 3-10.

Tevelev, A.S., 2011. Tectonics and Geological Mapping: Study Guide. GERS Publishers, Tver, Russia, Pages: 292.