

## STRUCTURAL MATERIAL SCIENCE

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### INTRODUCTION

The content of every paradigm consists of the system of scientific views based on the general model representations defined the entire set of conceptual, methodological, theoretical and experimental regulations [1, 2]. According to I. Prigozhin [3] such a system of natural scientific views forms scientific ideology. He noticed “...*the science is an ideology, it is also rooted in the culture*” [p. 49, 3]. According to the scientific ideology, a supporter of which I. Prigozhin was, one can argue that with the growing of internal conflicts inside the dominant scientific views the movement trajectory of this paradigm ideas gets in the bifurcation zone. It leads to the shift of paradigm and thereby it causes the displacement of scientific ideologies. A change of ideologies including scientific ones is a lengthy process often painful and tragic. It must be taken into account that it is talked not about replacement bad by good, backward by progressive etc. Drifting or change of paradigm implies the formation of a new system of views based on fundamentally different basic models.

Transition through the point of bifurcation changes the paradigm structure defining its content meaningfulness, the level of its methodological provision, theoretical saturation. The other ideological positions are forming, new scientific fields and schools are created which promote and develop becoming established paradigm ideas. The example is the change in the general scientific basic concepts of material (including building) science.

### 1. STRUCTURE IS THE BASE FOR ARCHITECTURE AND DEMONSTRATION OF BUILDING MATERIALS AND CONSTRUCTIONS

Simple, clear, accepted on faith the base model of building materials as the solid medium allows inventing the methodology of their assessment on the level of the average. The explanation of building materials mechanism formation is based

on the ideology of reductionism (lat. reduction – return, bringing back) that comes from the assumption that the whole can be understood just if its parts are understood. Ideas of allowable loads and strains those must be lower than limit values defined by laboratory, have formed the base of designed methods in products and constructions design. On this fundamental regulations many generations of ideologists of unstructured medium, its analysis and calculation and design methods both separate structural elements and structures, buildings and constructions with various kinds and purposes have been taught.

Ideology of unstructured medium implies an ambiguity of perception and evaluation of reality. There is the certain dualism in description of surroundings. There are originality and uniqueness of the processes and objects based on their structural dissimilarity on the one hand. There is unstructured medium on the other hand that is assessed average parameters of temperature, humidity and pressure. They differ in density and strength values, ratios of thermal conductivity, thermal expansion etc. Reality dissolves in the medium quality indicators accepted in the ideology of unstructured medium.

Emerged dualism can be considered as the beginning of the inner conflict within current paradigm. The system approach and synergy in its successful development arise from particular structure existing in objects of different nature and use. The holism ideology is forming (gr. *holos* – the whole, entire), the main point of it was declared by Aristotle (384 – 322 BC). He stated that the whole by its essence includes much more than there are summarized parts the whole consist of. The emergence and expression of something new is connected with the structural organization of objects-systems. The key parameter for creating the unexpected one is a structure. Accepting a structure as existing phenomena one can conclude that the ideological scientific positions start to change. Nicolay Gumelyov’s words are appropriate in this case “*the whole world is discovered again for me*”. The belief system ideologically oriented to the structure accountability for expressing and maintaining the properties of any object is forming.

In the evolution of different approaches and views a problem of terminology arises. Generally at the beginning existing terminology is used and some additional sense is given. Such a type of term that is widely used in different fields of knowledge is a term *structure*.

Widespread use of any term spreads its meaning to the blurriness. It is logically to say “*language structure*”, “*society structure*”, “*and metal structure*”, “*concrete structure*” and another ones. The term is used appropriately in biology, medicine, sociology, geology, mechanics, physics, chemistry, materials science and other sciences. The combined principal for objects not similar to their nature is certain hierarchy of their inner structure, inner architecture existed in the synthetic term structure.

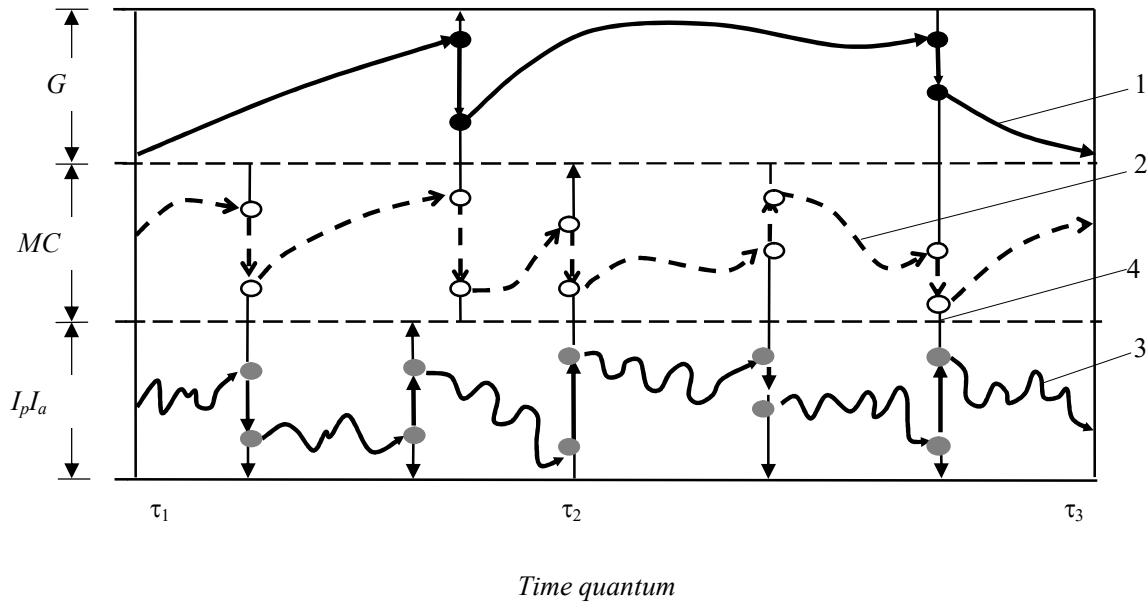
Generally the structure (lat. *structura* – arrangement, order) is understood as a set of stable relations of object satisfied its integrity and identity to itself. In another word it is preserving the basic properties at various external and internal changes [4]. Such definition provides the structure to reflect some fixed state of the object that allows evaluate and describe qualitatively and quantitatively its structure taking into account the interaction and the relative position of the totality of the structural elements and groups of them.

According to [5] structure can be considered as “*stopped motion*” as moment fixed condition of the system in the process of its development, as certain configuration of its components. It is worth to say that term “*structure*” is used successfully in the description of dissipative systems [6], cooperative phenomena [7], processes of self-organization and adaptation various systems [8] without accurate definition of the essential content. This was the basis to bring into the essential content certain dynamics and self-support in autopoietic system [9], systems which development goes with an exacerbation [10]. Quite a lot of individual definitions of the term “*structure*” in separate crystals, metals, polymers and other materials descriptions are suggested.

Multiplicity of concept definition assumes its informative insaturation, certain dynamics of becoming unpreparedness of entering the generalized all-satisfied senses. Therefore, it seems logical to limit directly the semantic meaning of the term by providing structure in the form of a specific *model* (lat. *modulus* – measure, sample) of the object [11]. This method allows focusing on the structural features of the object which are responsible for the manifestation of certain properties according to a specific subject. Choice of

model structure depends on the subjective position of a particular investigator – his ideological positions, research objectives, methodology, instrumental and material resources, etc. The subjective nature of the “*appointment*” of the structure dominant elements is contained in the method of expert evaluations that basically allow us to estimate prevailing ideology of community of professionals in a time interval. Therefore making a particular model the purpose of the structural description of a particular object (the mechanism, the process) must be defined. One of the purposes of the structural approach is identifying the structural controllable factors which allow the structure to reproduce a required set of structural elements. To do this fixing a large-scale description of the boundaries and establishing a number of prioritize structure elements are needed to ensure the purpose of the object of analysis.

Many studies are devoted to allocation the scale levels on the size principle in the description of the structure of different nature materials (e.g. [12, 13]). There are supposed to allocate the levels of structural inhomogeneities on the basis of similarity of structural organization mechanisms in the publications [11, 14, 15] that allows to describe a product or constructional integral structure presented in the form of a system of a certain kind [16]. In the process of analyzing the structure organizational mechanism the borders of scales were found taking into account the principal difference in the processes implemented under the influence of force of gravity from the processes that almost do not react to the forces of gravity. V.I. Vernadskiy [17] noticed that macroscopic niche exists where a worldwide attraction reigns. He emphasized that a spatial multiscalement associates with timing multiscalement. This position is similar to H. Bergson’s statement [18] that multiple of levels of time and a multiplicity of life worlds exist at different levels. It is pertinently from our point of view to mention E. Petiot’s [19] conclusions about emergency (eng. *emergence* – appearance of a new one) existence and display two (at least) different levels of organization are required – one is underlying “*micro*” and another phenomenal “*macro*” observed at various spatial and temporal scales. The compulsory presence of a time series is noteworthy when the complex behavior of complex systems is considered [20, 21, 22]. A priori we will proceed from the time invariance (lat. *invariants* – unchanging) at different spatial scale levels without analyzing the nature of time. Within certain time slot (time quantum) the number of taking place and implemented events are



**Figure 1.** Diagram of multiscaled interactions.  $G$  – scale level where gravity proceeds;  $MC$  – scale level where gravity and interparticle interactions can proceed;  $I_p I_a$  – scale level where interparticle interactions proceed; 1, 2, 3 – events at multi-scale levels of structure; 4 – interactions between the structural components at multi-scale levels.

fundamentally different, up to impalpability and therefore insensitivity [20].

The principal scheme of different scale structure coexistence is shown on the fig. 1.

The certain scale level, involved in the level of metastable state (MS) where individual particles and their families can reside in a metastable state, is allocated in a separate level. In the case of disintegration of the unit or particles cleavage from it (caused by physic and chemical, physical and physical and mechanical processes) the last transfer at the level where gravity is not dominant. When particles are combined into structural aggregates which weight is higher than force interactions of particles aggregate they fall under the effect of gravity automatically. It can be supposed that MS-level is a link (horizon of events) between two spatial levels. These levels differ from each other as the causes of certain events as their number occurring during a certain time quantum.

The difference between the mechanisms of structure formation at various spatial levels and the implementation of these acts of structure organization basically not matching in time suggest a certain level of independent existence. Processes occurring at every level subject to the laws manifested at this level, and cannot be carried out at another scale level in most cases. Impact of an event from one level on occurrence of events at another one relates to the rank of external events and occurs usually in mismatched time slots. It means certain autonomy of developments at every

level and a certain coexistence of diverse events in the whole system. It can be argued that this coexistence, realized through interaction of diverse events, provides the appearance of new (the other) qualitative characteristics of each scale level and the system as a whole.

Here the events are understood as a set of processes and phenomena of different nature implemented at different spatial scales for different time quantum. The problem arises to associate flows of events related but fundamentally different in essence occurring at different spatial scales and during different time lengths. It needs to identify elements that can be present at all scale levels simultaneously or belong to a specific spatial level and which are capable to provoke the birth of a certain event by their presence, fig. 1.

In order to determine these elements the task is to trace the formation history of the structure of a particular object. In publications [11, 14, 15] it is underlined that geometric characteristics of a particular product have a significant impact on the structure which components are local and integral field of residual (primary, technological, hereditary) deformations. It allows conclude that directed organization structure with a set of structural elements arises from the impact of the individual characteristics of a particular product. Geometric image of a specific object creates a unique qualitative and quantitative ratios of the structural components at different spatial levels with temporal difference of initiation of events displaying. The

geometrical parameters of objects should be regarded as significant management factors of the initial structure organization becoming the object-product. Thus the developed model of the structure should be related to a particular object (products, constructions, etc.).

## 2. THE ELEMENTS OF STRUCTURE OF OBJECT-SYSTEM

Structure models of a particular object should contain elements aimed at ensuring sustainable relationships to ensure the integrity and identity of the object under the action of all operational loads. An earlier analysis [14] allowed us to offer a classification of structural elements based on the difference in the speed of response of various elements when object is subjected to external and internal factors. In general case conservative metastable and active elements are marked.

Conservative (lat. *conservation* – saving) structural elements include elements changed their parameters slow enough during period when object functions. Usually conservative elements belong to the large-scale level where dominant force is gravity and phenomenological approaches of properties evaluation are implemented.

Elements of the structure which are relatively stable under these conditions and able to spontaneously going in the stable or unstable state by the action of external or internal factors are referred to the metastable (gr. *meta* – between, after, through) elements of the structure.

The hallmark of active (lat. *activus* – activities) structural elements is their ability to respond adequately to the proven impact in proportion time interval (one tempo rhythm).

Under the structure elements (lat. *elementum* – element, the original substance) various scale components of the system with specific features ensuring certain functions that contribute to the objectives of each structure level and the system as a whole are suggested for understanding. Structure elements may be specific material formation (e.g., components of the system, the pores and capillaries, cracks, etc.) of the system defining its internal state (e.g., local and integral technological and operational strain, osmotic phenomena, etc.).

System gets the entire set of structural elements in the form of building products and constructions [14] in the process of concrete receiving and its processing into products. At this stage, all the original members are actively involved in multiscale structural design with the formation of

new structural elements of the becoming system. The situations are not excluded where creating intermediate structural formations initiate the formation of the intermediate structural birth and development of fundamentally new elements included in the structure of the final product. Equifinality effects are characteristic (lat. *aequus* – equal proportionate; *finalis* – final). In our case it means the implementation of the structural organization of the various mechanisms that lead to the emergence of qualitatively identical structure elements. As examples, the origin of technological cracks is considered: - in the formation of discrete structures at the product level and at the level of tumors interaction of initial grain mineral binders; - in the development of gradients of own strains at the interfacial hardening matrix material and fillers; - under the influence of emerging gradient deformation at the level of product structures [11, 14].

A kind of "*albums portraits*" multiscale structures coexisting on different time scales are created as a result of mutual influence and interaction of all elements at all levels of irregularities. "*Albums of portraits*" means the permanent dynamics of structural components the totality of which defines a "family portrait" of the structure within a fixed time interval. In this context, a comparison with a "family portrait" suggests that at the same time it has all the elements of the family system. Thus the construction-system comes into the active phase of operation with a set of conservative, metastable and active elements of the structure. Further safe operation of the construction-system depends on the ability of the structural elements by self-consistent interactions and by transforming their own parameters to ensure the preservation of the system properties within continuous operational loads exposure.

Ensuring the stability of the properties for the required time of operation raises the problem of exception and analysis of models and structures in which adaptation processes (lat. *adaptation* – adjustment) can be implemented by percolation phenomena of self-organization at all various scales and multi time levels of construction-system. Adaptation of concretes [23, 24] should be attributed to the underlying determinants of the viability of products-systems. Therefore a prioritize number of elements that can alter the periods of adverse events should be defined in the model of the structure. This will identify the main governing factors aimed at creating a "*family portrait*" of the construction-system structure operated under adverse external influences.

### 3. CONCLUSIONS

A structured approach at this stage of its development should be considered as "an introduction to the explanation" of the mechanisms and processes of creation and functioning of various types and purposes systems. It is based on the becoming scientific ideology based on the ideas and methods of a systematic approach and synergy for which the term "structure" is the dominant concept. There are a paradigms shift based on the basic model of continuous medium in the direction of paradigms based on models of a structured self-developing medium. The fulfilled analysis has led to the conclusion that geometrical characteristics are one of the factors influencing the mechanisms of formation of building products and constructions. Therefore studying the structure of the material without his registration in some constructive forms is futile. In addition due to blurring and information uncertainty generalized definition of the term "structure" it is proposed to develop and analyze models of the structure of concrete products and constructions. The effect of the spatial levels of different scales in the mechanisms of the individual structures of each level of interaction and mutual influence taking into account the number of mismatches ongoing events over a fixed time slot to form an integrated structure construction-system should be taken into account. This allows us to consider the structure in a certain dynamics of development both in the establishment of the system and the action of its duty operation. It is proposed to classify the elements of the structure by the time of their response to external and internal influences on the conservative metastable and active elements of individual subsystems and the system itself.

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