ROLE OF OWN DEFORMATIONS OF HARDENING BINDER IN CONCRETE STRUCTURE ORGANIZATION

Vyrovoy V., Korobko O., Sukhanov V., Kotsyurubenko O.

Odessa State Academy of Civil Engineering and Architecture, Ukraine

Abstract

Relationship of the deformation phenomena which determine development of the concrete structure organization is analyzed. Concrete is studied as a polystructural material. Its structure formation is defines by interference of levels of concrete structural heterogeneities on initiation of returnable waves of their own deformations. The conditions for self-generation and self-development of technological cracks, inner surfaces of partition, and set tensions are created. Their interaction provides the integrity and the manifestation of concrete properties in products. Mutual conditionality of the phenomena of the concrete structure organization at various levels of heterogeneities is an objective process. This knowledge is necessary to take into account at setting the compositions and technological modes of building constructions production.

Introduction

Building constructions can be presented as complex self-organizing systems. This point of view suposses their existence and function as complex organized aggregate of interconnected subsystems [1, 2]. As one of subsystems it is possible to select a concrete as the subsystem consisting of the certain community of own structural heterogeneities – individual components of concrete structure [3]. At each level own mechanisms of the organization of structures which interact by means of surfaces of partition are realized [4]. Structural levels of concrete coexist and realize itself in the general coherence of interactions. It allows considering the structure of concrete as a result of certain processes which initiate the interdependent structural changes of its separate component parts. To such processes it is possible to refer own deformations which arise up as a result of manifestation of physic-chemical and physic-mechanical binders hydration processes. Developing deformations are passed on the other levels of heterogeneities that cause formation of returnable wave of deformations. Thus, there is influence of own deformations on organization of concrete integral structure. This process estalished the task of researches – to analyze the mutual conditionality of the deformation phenomena, which determins development of organization processes of concrete structure.

Models of structural heterogeneities of concrete

In the concrete structure heterogeneities can be distinguished at the level of particles of binder as a microstructure, at the level of new growths products as a nanostructure, at the level of matrix composite and fillers as a macrostructure and at the level of product (constructions).

Choosing the structural heterogeneities models certain suppositions and assumptions are accepted. The microstructure of concrete can be presented by such heterogeneity type «particle of a dispersible phase – the dispersive environment» as the multiphase heterogeneous high-concentrated coarse-dispersion lyophobic system with lyophilic limit

of phases partition [5]. The macrostructure of concrete can be presented as a coarse-heterogeneous system, consisting of matrix, in which fillers are distributed, with formation of structural cells, different in properties and parameters [6]. Matrix material is accepted as a heterogeneous environment with a complex inner organization. The nanostructure of concrete is presented by levels of structural heterogeneities types «products of new growths – the dispersive environment» and «products of new growths – particles of dispersible phase» [7].

Microlevel structure organization occurs by means of unbalanced interactions between particles [8]. The nanolevel as a subsystem is a part of a microstructure. Formation of a nanolevel is associated with thermofluctuational effects manifestation and achievement of critical values of concentration factor of a nucleation of ions in a new phase [9]. Thus the microstructure itself is a component (subsystem) of a macrolevel. As a matrix material microstructure determines its structure organization features at interaction with fillers [10].

The structure of concrete at the level of a product is allocated as integrity. A construction and material it's made of exist in this integrity as equals [1]. It means that structural features of a material are included in structure of construction.

Summarizing the said above, the structure of concrete can be presented as a certain hierarchy of levels of structural heterogeneities, which act like subsystems regards the concrete, but they are systems for the structural components. The structure organization at all allocated heterogeneities levels is accompanied by development of deformations, which are initiated in a microstructure, participate in the organization of a macrostructure and they are shown at the level of a product.

Influence of own deformations on processes of the concrete structure organization

Concrete structure formation is defined by the interference of levels of concrete structural heterogeneities. It is shown in reflecting the one level structural transformations on the structure organization processes of the other levels and parameters of their structural components. The realized changes serve as the reason for changing initial structures. Thus, interaction and mutual initiation of structural design of various levels is executed. Thus course of concrete structurization processes is accompanied by self-development of a mutually coherent network of the inner deformation phenomena (Fig.1). Thus levels of heterogeneities can initiate only structural changes of other levels, but not operate them.

Motivation (incitement) to the beginning of the organization of levels is provoked by their inner reasons.

When integrated structure of concrete as self-organizing system is forming the dominant position is occupied by processes and the phenomena which are realized at the level of binder particles. It is due to the fact that all subsequent structural transformations of concrete at all levels of heterogeneities are defined by the organization of a microstructure. In its turn, conditions of structurization of microlevel depend on its inner characteristics and the parameters of macrostructure, which subsystem it is. Thus the processes connected with allocation of disperse particles on cluster structures are of fundamental value.

All particles are integrated by a difficult network of the interrelations proving in depending on distance between them, their sizes and the nature. As the result formation of clusters of the mixed and uniform structures, various forms and sizes are ocurred. It defines features of interdependent courses both interactions between clusters, and physic-chemical processes of the organization of a microstructure. It allows assuming individual

conditions of binder particles hydration in local volumes of microlevel and possibility of their directed providing by the induced action of inner and external structure-forming factors.

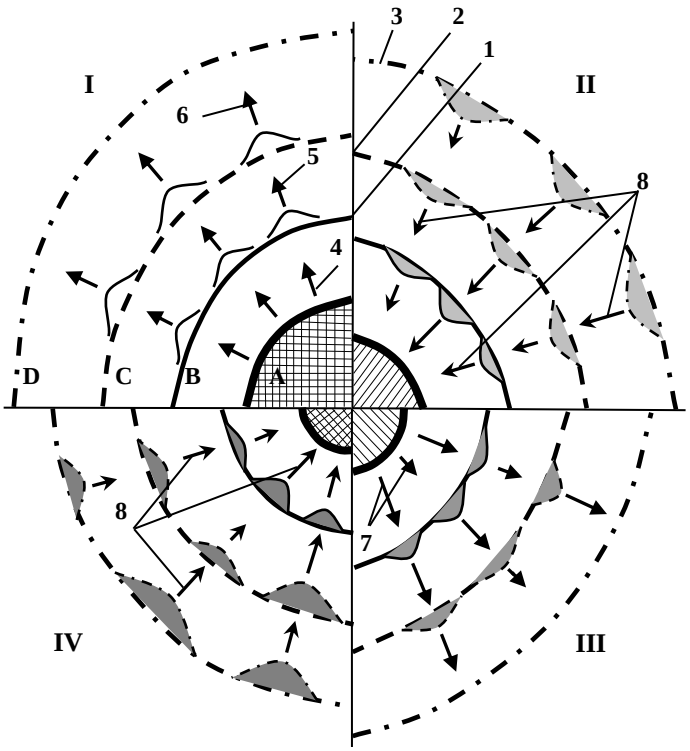

Figure.1. Self-development of a mutually coherent network of the inner deformation phenomena at the organization of concrete structure:
I, II, III, IV – stages of own deformations development.

A – the sourse of the deformations beginning; B – the level of a microstructure of concrete; C – the level of a macrostructure of concrete; D – the level of a product; 1 – surfaces of partition «microstructure – fillers»; 2 – surfaces of partition «macrostructure – product»; 3 – external product boundaries; 4, 5, 6 – concrete heterogeneities deformations of appropriate levels; 7 – gradients of deformations caused by further course physic-chemical processes of concrete structure organization; 8 – returnable deformations varied in size and direction.

Surfaces of partition at first between separate grains of binder and tempering water, and then between a surface of structural aggregates and the dispersive environment are sated with products of binder grains hydration. Particles of a new phase, owing to the nanometric size, can't coexist separately in the environment with the same ones, and through interactions between partials they form rather stable connections – nanoclusters which enter into interactions with each other. Therefore structures of the following level of structural complexity are thus formed. All set products of new phase is connected by a certain relations sort. It allows presenting a new phase as nanostructural heterogeneity of

concrete in the form of self-organizing system with characteristic for it mechanisms of structurization and a unique set of substructures.

The organization of nanostructure is carried out within interpartial and intercluster limits of partition of microlevel which structure it is included in. Surfaces of partition between separate particles and aggregates of microstructure according to the characteristics differs in a considerable variety. It is connected with originality of allocation on structure and sizes as grains of binder in structural blocks as blocks in volume of microlevel. It predetermines uniqueness of conditions of formation of separate nanostructural components and change of their volume that provokes gradients manifestation of volume deformations on limits of partition of a microstructure. Thereby probable ways of further course of deformation processes in concrete structure are set.

The initial stage of manifestation of deformations is realized at micro- and nanostructures levels and a sourse of their beginning physic-chemical processes of the concrete structure organization at the level of binder particles are a source of deformations (Fig.1, Stage I, Level B). Allocation of binder particles on structural aggregates provides formation of the interconnected set of intercluster limits of partition at microlevel. At the same time surfaces of partition between a microstructure as a matrix material and fillers are formed (Fig.1, Stage I, Levels C and D). Fillers as structural components are included into structure of material at the level of a product. It should be considered that participate directly in processes of the organization both own structure and structure of other levels limits of partition of all concrete structural heterogeneities.

Appearing and development of nanostructural heterogeneity initiate manifestation of volume deformations which are perceived by inner surfaces of partition of a microstructure. The initial deformation wave as a result of which gradients of volume changes of the microlevel, caused by fluctuations of its material compositions, are transferred to level of macrostructure, establishing gradients of its own deformations. It conducts to spontaneous forming of surfaces of partition between a matrix and fillers, unique for each structural cell depending on its parameters.

Gradients of volume deformations of a macrostructure of concrete define deformation processes of a material at the level of a concrete construction (product). Uniqueness of these course processes in its separate volumes stipulate uneven allocation of the set tensions fields caused by local changes of density in a material. It serves as the reason for reallocation of gradients of deformations and causes a returnable wave of their influence on macro- and microstructures levels (Fig.1, Stage II).

Manifestation of different-sized and multidirectional volume deformations of concrete structure at the level of a product initiates further form changing surfaces of partition of a macrostructure. It is reflected in proceeding physic-mechanical processes of structurization of microstructural heterogeneity and conducts to even bigger variety of its structural components. As the result, course conditions of physic-chemical processes of the structure organization of microlevel are changed. It influences on kinetics of nanostructure structurization with excitement in it a new wave of the deformations which gradients are perceived and transferred by inner and external limits of a microstructure to surfaces of partition of macrolevel and concrete structure at the level of a product (Fig.1, Stage III). Thus, consequently there is a mutual initiation of returnable waves of volume deformations transition from level to level that allows structural heterogeneities to cause each other structural organization. It depends on the intersystem characteristics (Fig.1, Stage IV).

Mutual initiation of transition of deformation waves from one level to another provokes changing of their limits geometry. Thereby conditions for beginning and

development of technological cracks and inner surfaces of partition are created. Thus, as the powerful control factor it is necessary to allocate geometrical parameters of each level of concrete heterogeneities. In a microstructure dispersion and quantity of binders particles can be referred to such parameters mentioned above. They define geometrical registration of cluster structures and intercluster surfaces of partition consequently. At the level of nanostructure the sizes and a form of aggregates from products of new phase are of fundamental value for parameters of nanometric interblock limits. The geometry of macrolevel is defined by type of placement and orientation of fillers which the configuration of limits of the matrix material concluded between them depends on. At the level of a construction geometrical characteristics of concrete are set by a form and the sizes of external limits of a product as complete object.

Change of separate levels geometry of heterogeneities allows determing conditions of the organization both their own structure and all concrete structure through interference of parameters. It is confirmed by experimental researches on physical models. Results showed that the form of products initiates beginning of gradients of technological deformations which influence on macrolevel as a returnable wave. Various parameters of a macrostructure lead to change aggregates sizes from binder particles to 2 times, setting time of a matrix material for 15-35 minutes, and the value of volume deformations to 30%. These data point to the possibility of the directed concrete structure organization on a nanolevel as source of appearing of deformations for receiving materials with demanded heterogeneity. Experiences showed that at various geometrical characteristics of samples the coefficient of their technological damage can change to 40%, and water absorption – to 25%.

The structure organization, both separate levels of heterogeneities and the concrete, occurs under continuous action of being formed streams of their own deformations. Deformation waves provoke a self-generation and self-development at all levels of heterogeneities various sorts of flaws which as new elements automatically join in the organization of their structure, participating in manifestation and allocation of gradients of deformations. Thus there are preconditions for beginning of such concrete structural components as technological cracks and inner surfaces of partition which together with set tensions define heterogeneity of a material of a construction, and therefore safety of its operation.

Conclusions

The analysis and researches allow to conclude that concrete is a polystructural material with characteristic levels of structural heterogeneities. In its turn, each level can be allocated in the form of set of separate but the interconnected substructures with a unique set of elements. Heterogeneities interact with each other through surfaces of partition, and interference of their parameters defines the organization both of their own structure, and integrated structure of concrete. Processes of the spontaneous structure organization lead to the beginning of new structural elements, which provide integrity manifestation and concrete properties in products by means of their interaction and interference. There are self-generation and self-development of technological cracks and the inner surfaces of partition participating in structural self-creation of levels by mutual initiation of deformations at various levels of heterogeneities. Deformation waves arising at the level of nanostructure influence on the organization of micro- and macrostructural heterogeneities. They define form-changing of surfaces of partition of concrete at the level of a product by means of transfer of deformations gradients. It initiates returnable deformation processes at levels of macro- and microstructures, that conducts to the

successive changes of their structural organization and excitement of a new wave of deformations. Thus, the interdependence of the phenomena of concrete structure organization at various levels of heterogeneities should be known as an objective process and it must be considered when compositions and technological modes of production of particularly products and constructions are set.

References

1. Vyrovoy V, Korobko O, Sukhanov V, Parkhomenko R: ′Building products and constructions as open complex self-organizing systems′. 7nd Int Conf Presenting, Voronezh State Architectural and Building University, 2013.

2. Prangishvili I: System approach and system-wide patterns. Series "Systems and management problems. Moscow, SINTEG, 2000.

3. Solomatov V, Vyrovoy V, Bobryshev A, etc: Polystructural theory of composite building materials. Tashkent, FAN, 1991.

4. Solomatov V, Takhirov N, Shakhekh Shah: Intensive technology of concrete. Moscow, Stroyizdat, 1989.

5. Solomatov V, Vyrovoy V, Dorofeev V, Sirenko A: Composite building materials and constructions of the reduced material capacity. Kiev, Budivelnik, 1991.

6. Uriev N: Highly concentrated disperse systems. Moscow, Khimiya, 1980.

7. Vyrovoy V, Dorofeev V, Sukhanov V: Composite building materials and constructions. Structure, self-organization, properties. Odessa, TES, 2010.

8. Solomatov V, Vyrovoy V: ′Formation of clusters of composite building materials′. Technological mechanics of concrete 1985 21-5.

9. Shpynova L, Chih M, Sanitskiya M, ets: Physical and chemical bases of formation of structure of a cement stone. Lviv, Vyshcha shkola, 1981.

10. Delmon B: Kinetics of heterogeneous reactions. Moscow, Mir, 1972.

11. Budnikov P, Gistling A: Reactions in mixes of solid substances. Moscow, Stroyizdat, 1971.

12. Vyrovoy V, Dorofeev V, Fits S: Concrete in the conditions of shock influences. Odessa, Vneshreklamservis, 2004.

13. Dorofeev V, Vyrovoy V: Technological damage of building materials and constructions. Odessa, Gorod Masterov, 1998.