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COMPUTER SIMULATION OF STRUCTURAL DEFECTS OF CONCRETE SAMPLES

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This article discusses the issue of the effectiveness of using computer simulation in the study of the deformation characteristics of concrete. An analytical review of the works, the authors of which were used computer simulation tools. The complex computer-aided modelling of the structure of concrete was considered using the programs VCCTL, MSC.NASTRAN, SolidWorks, ANSYS. Improving the methods of computer modelling of the behavior of structures made of composite materials will allow to optimize their resistance to destruction, strength, attrition resistance and other parameters.

Computer simulation of testing building elements and structures is an important task in the construction industry. Linking the results of virtual and real tests, we get a deeper analysis of the ongoing structural changes in the studied systems. Providing a correlation between these two research methods, the most rational and optimal results are obtained. Further, there will be an overview of domestic and foreign works of authors involved in the simulation modelling of concrete structures.

The article [1] discusses approaches to solving problems of deformation of structures made of composite materials by the finite element method. Examples of modelling composites using elementary cells of the material and based on real microstructures are given. The authors presented the results of calculations of concrete and reinforced concrete structural elements taking into account the internal contact interactions between the composite matrix and the reinforcing phase. It has been established that it is advisable to use modelling of the real structure to simulate the behavior of materials without any noticeable regulation of the structure, as well as analysis of the formation and development of cracks in materials. It is said that a significant drawback of this approach is the need to create a new complex model for each material microstructure under consideration, which does not allow the effective use of this approach to improve the material or parts made from it.

The work [2] is devoted to the finite element modelling of the stress-strain state of a composite reinforcement with spherical granules. There is the investigation of influence of the size of the granules and the adhesive properties between the phases of the composite on the stress-strain state of the material. A periodicity of a cell was adopted as a computational model, including parts of two granules and the surrounding matrix. The contact interaction of the granules with the composite matrix was taken into account. Thus, the application of the elementary cell modelling method, which takes into account the contact interaction between the matrix and the reinforcing phase made it possible to establish the features of the stress-strain state of the composite material. Reduction of the size of the reinforcing granules leads to a significant improvement in the adhesion of the granules with the matrix.

The authors of [3] proposed a structural-imitation model of the macrostructure of lightweight concrete and its components - cement-sand stone and porous aggregate. Using the methods of fracture mechanics, the development of initial structural defects under load is described, the effect of macrostructure parameters on the strength of lightweight concrete is experimentally evaluated.

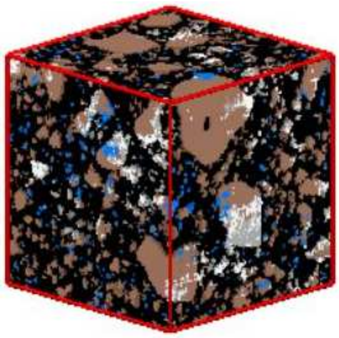
The article [4] describes the joint work of phases that are heterogeneous in properties within the framework of structural-imitational modelling of composites. In this article, the author demonstrated the stages of modelling various elements of concrete: matrix, aggregate, fiber and pores. These stages include:

- creation of geometry and orientation of elements in space;
- the appointment of effective properties;
- consolidation of the created model;
- testing (loading) of the created model.

Various variants of the geometric form of the aggregate, pores are presented, the ranges of variation by their characteristic dimensions and orientation in space of the cement matrix are indicated. This article is the basis for a computational experiment, which includes all the above steps to obtain new data on the process of gradual accumulation of damage in the structure of fibrous concrete under static load. and MSC.PATRAN-NASTRAN), developed by specialists in this field

The mechanism of concrete destruction, is associated with the formation and development of micro- and macrocracks under the action of the load. The reason for the appearance of the first microcracks is the stress concentration near the structure defects: pores, inclusions, dislocations [6]. The peculiarity of the stress-strain state of micro- and macrocracks is that the material in the dead-end part of the cracks works beyond the elastic limit. Since the size of the dead-end part of the crack is at the atomic-molecular level, the non-linearity of the material is determined by the nature of the interatomic interaction forces [3].

To simulate the microstructure of concrete Virtual Concrete and Cement Testing Laboratory (VCCTL) was used [5]. This program was developed by the National Institute of Standards and Technology (NIST), USA. The program models 3D - microstructures of cement systems and allows predicting the final properties of the resulting composite. The hydration of these microstructures can be modelled according to different hardening conditions, and the resulting hardened material can be analyzed for a number of properties, including linear elastic moduli, compressive strength and relative diffusion coefficients. 3D - packaging of small and large aggregates in mortar and concrete mixtures can also be created. In connection with the transition of the country to the European standard (TKP EN), this program is also relevant for the Republic of Belarus [8].



a)

b)

a) Visualization of the microstructure of concrete in the VCCTL [5];
b) General view of the concrete sample
Figure 1. – Presentation of the modelling of the structure of a concrete sample

To correctly determine the residual life of the structures, the source data must be determined from the results of field tests and measurements. Unfortunately, for most structures, obtaining reliable source data is difficult, which naturally reduces the accuracy of calculations [7].

Studies that are carried out in [8–10] should be supplemented with computer simulation results, which will give a broader picture of the processes occurring in concrete structures and will allow optimizing the data already obtained taking into account their structure at various levels of organization. Further tests are planned to be carried out in accordance with the most promising areas of concrete structure simulation. The virtual test algorithm involves several steps:

1. Simulation of microstructure and prediction of the operational properties of concrete (VCCTL software);
2. Creating a complex structure of composite material (SolidWorks);
3. Virtual testing of the obtained model (ANSYS);
4. Calculation and visualization of crack formation in the studied model (MSC.PATRAN-NASTRAN).

In conclusion it must be said that the task of structural simulation modelling of composite elements is complex and requires careful study of the components at each of its stages.

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