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REPORT

on the PhD thesis presented by NIKOLAI SERGEEVICH MARKOV titled

***ON PROBLEMS OF MECHANICS
FOR THE LAYERED STRUCTURES WITH INHOMOGENEITIES***

submitted for the Candidate of Science degree in specialization 01.02.04 - Solid Mechanics

The thesis is devoted to an actual topic in solid mechanics - the behavior of layered structures with inhomogeneities that have many applications in materials mechanics or physics, civil engineering, soil mechanics, mining, electrical engineering, optics, hydrodynamics, etc. Both analytical and numerical methods are used if such problems are investigated. Numerical methods like the finite element method, the boundary element method, and the particle dynamics method are necessary for real problems, but for testing numerical codes benchmarks should be applied. Such benchmarks are often based on analytical or semi-analytical approaches.

Finite element methods and particle dynamics require significant computational power to simulate processes occurring in layered media. The boundary element method is sense has advantages, but there are also limitations - the Green's function for a structure without inhomogeneities must be known. Otherwise, the Green's function of a layered medium can be established numerically. The methods for calculating the Green's function for layered structures presented in the literature are not applicable for all cases. As an example, the modeling of crack growth in an elastic layered medium under the influence of internal pressure can be mentioned. In addition, such problems cannot be solved using homogenization methods.

In the present thesis, the Green's function for layered structures is computed using the Fourier transform for the Laplace operator and the three-dimensional Lamé operator is tested and generalized, as well as the pseudo-three-dimensional model of a hydraulic fracturing is modified to increase the accuracy of calculating the geometric parameters of the fracture. The application of the boundary element method and the introduction of the developed approach into existing models used to solve applied problems made it possible to compare the new results obtained in this work with existing solutions.

Mr. Markov formulates the scientific novelty of his thesis as follows:

1. The method of constructing the Green's function for layered structures is extended to the case of harmonic problems and three-dimensional problems of the elasticity theory.
2. A generalization of the complex variables boundary element method to problems on layered structures with inhomogeneities for the two-dimensional Laplace equation is given.
3. The problem of a radial fracture perpendicular to the boundaries of the layers under the influence of uniform pressure in a in an infinite three-dimensional three-layer elastic medium is solved.
4. A method for calculating the speeds of the height growth of a pseudo-three-dimensional hydraulic fracture in the viscosity-dominated regime in a layered medium has been developed.

All this four items are investigated in detail in the thesis. A special focus was made on the investigation of the accuracy, on the formulation of limitations of the given methods, and finally the results were compared to known solution in the literature.

The thesis is presented on a high scientific level using the direct tensor calculus. The literature survey is excellent. The examples illustrating the theoretical part in a proper manner. There are no critical remarks.

Despite the above-mentioned remarks, the thesis deserves to be positive evaluated.

The thesis of N.S. Markov "On Problems of Mechanics for the Layered Structures with Inhomogeneities" fulfills the requirements established by the decree "On Order of Granting Degrees in St. Petersburg State University". Nikolai Sergeevich Markov deserves to be granted with the Degree of Candidate of Physico-mathematical Sciences (Specialization 01.02.04 – Solid Mechanics).



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