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6. Сметанкіна Н.В., Шупіков О.М., Угрімов С.В. Математичне моделювання процесу нестаціонарного деформування багатошарового осклiння при розподілених та локалізованих силових навантаженнях. *Вісник Херсонського національного технічного університету*, 2016, № 3(58), с. 408–413.

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MODELLING OF INHOMOGENEOUS SHELL ELEMENTS DEFORMATION UNDER STATIC AND DYNAMIC ACTIONS

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A mathematical model is proposed to study the influence of the characteristics of shock-absorbing elements on the stress-strain state of reinforced concrete shells with cutouts under the influence of a vertical component of a seismic wave.

Currently, the problems of design and construction of building structures are becoming much more complicated due to the increased anthropogenic load on buildings and structures, as well as to the increased requirements to the parameters of strength reliability, the need to reconstruct the operated objects, to assess their survivability and residual resource [1–3]. However, even in normative documents on design of reinforced concrete spatial structures there are no examples and practical recommendations on calculation of most types of shell structures [4–7]. This necessitates the development of adequate design models that take into account, in addition to physical, mechanical and structural features, the so-called “complicating” factors: nonlinearities of geometric and physical type, since the considered features of deformation of spatial building structures can be described only from the standpoint of the nonlinear theory of plates and shells [8–10]. It should be noted that both in the current and in the developing normative documents on strength calculation of reinforced concrete building structures the necessity to take into account nonlinear effects in calculation models is noted [11, 12].

During operation, thin-walled reinforced concrete building structures, depending on their purpose, experience the impact of a whole complex of static and dynamic loads of different nature and character: gravitational loads (weight of bearing and enclosing structures); atmospheric loads (snow, wind, temperature); loads caused by the displacement of the earth's surface (seismic); technological loads; loads caused by extraordinary circumstances (explosions, fires, various emergencies) [8, 12].

It should be noted that among the variety of forms of thin-walled structures, the most common in construction are bearing and enclosing elements in the form of shells of rotation. At the same time, in most cases the structures have some features and heterogeneities: local or general thickness variation, presence of cutouts, anisotropy of used structural materials, etc. A characteristic feature of the behavior of large-span shells under the action of applied loads is the occurrence of maximum displacement fields comparable to the shell thickness and exceeding it, which also causes the need to use the relations of geometrically nonlinear shell theory in the study of the deformation features of such building structures, i.e. to perform the calculation according to the deformed scheme.

Since practical development of the behavior of structures on the basis of full-scale physical experiment is, as a rule, associated with significant difficulties, computational experiment, which consists in the study of real processes by methods of computational mathematics, is widely used nowadays to investigate the features of deformation of plates and shells under various types of loading. The most important stage of computational experiment is the design and development of adequate mathematical models, economical numerical methods and algorithms and their practical realization in the form of packages of applied programs for computers. The use of such packages significantly reduces the time of design work and makes it possible to optimize the design for a wide range of structural, technological, operational and economic requirements.

The aim of this work is to develop mathematical models for studying the processes of nonlinear deformation of inhomogeneous spatial elements of building structures in the form of shells of rotation under various types of static and dynamic loading. Within the framework of geometrically nonlinear relations of Timoshenko shell theory, adequate mathematical models and effective numerical methods have been developed and elaborated on the basis of the variation-difference method, which make it possible to study the features of deformation of inhomogeneous multilink shell elements of building structures under the action of static and dynamic loads of various types, including seismic ones. A mathematical model has been developed for dome-type shell structures mounted on a cushioned foundation slab, which makes it possible to study the influence of the characteristics of viscoelastic cushioning elements on the stress-strain state of reinforced concrete shells with cutouts under the action of a vertical component of a seismic wave on the basis of dynamic calculations.

For the transition to the discrete finite-difference analog of the original continuum problem, conservative variation-difference schemes have been developed that allow one to study nonlinear deformation of plates and shells with cutouts on the basis of simple, orthogonal meshes of regular structure and finite-difference operators of the second order of approximation.

Within the framework of simplified linearized relations, formulas for estimating the optimal values of the parameters of the iterative process in the calculation of reinforced concrete shells are obtained.

Conclusion.

Thus, a practical criterion for determining the optimal values of parameters of viscoelastic shock-absorbing elements based on comparison of amplitude-frequency characteristics of a seismic wave and a shock-absorbed foundation slab in the case of periodic and limiting aperiodic motion is proposed.

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FUNDAMENTAL RESEARCH OF MATHEMATICAL MODELS FOR COMPLEX SYSTEMS

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The article examines the peculiarities of implementing mathematical models for complex systems. The authors pay particular attention to defining and substantiating the conditions for the correctness of boundary value problems that describe the state of complex systems.

Mathematical modeling is used to record physical phenomena in complex systems through mathematical expressions, based on causal relationships between the components of modeled systems and analysis of their properties. It should be noted that the constructed mathematical model must unambiguously define the modeled system. This is achieved because this mathematical model meets the condition of adequacy to the modeled complex system, and therefore a change in the initial data of the system leads to a change in the right-hand side of the differential equation and boundary conditions. According to the functions of mathematical models, structures, and behavior over time, there are functional, structural, informational, and behavioral