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Stability of Individual Phases in the Elastic Matrix of a Composite

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Abstract. A methodology for analytical stability assessment of individual compressed flexible phases of discretely heterogeneous composite elements of engineering structures is proposed to ensure their reliable safe operation and minimise the consequences of emergencies. Based on the energy balance equation for the proportional forces of a normal resistance of the medium to the phase displacement, expressions are obtained for determining the critical force, taking into account the possible initial curvature (non-rectilinearity) of a single phase in the elastic medium of the matrix for three possible cases of stability loss. The approbation of the results of the study on the example of deformation features of reinforcing bars in a compressed reinforced concrete column is presented.

Introduction

Various composite elements made up of a basic matrix material and individual discrete phases (bars) have been widely used as the elements of engineering structures of various branches of mechanical engineering and construction. Such composites are traditional reinforced concrete, fiberglass, carbon fiber, etc. Separate high-strength and flexible phases of the composite element can be in a compressed state, which can cause a loss of their stability and subsequent destruction of the matrix and the entire composite element. Since such destruction occurs instantly without characteristic external signs, it can become the cause of an emergency situation. Therefore, along with identifying the criteria for stability loss of a composite element, it is also important to control the probability of stability loss of its individual phases in the elastic environment of the matrix. Structural solutions (putting in rigid diaphragms – clamps) do not always lead to the desired effect, as phases in a relatively strong matrix (elastic medium) may lose stability not over the entire length between clamps or according to the form with several half-waves, when clamps only define places with zero displacements and have no effect on the critical force value. In addition, reinforcing bars (phases) can have an initial curvature caused by sags, transverse deformations or various other causes (defects). Such features of deformation of the compressed phases of composite structures need to be studied in depth to minimise the consequences caused by the unexpected failure of composite structural systems.

Analysis of Publications

The mechanics of deformation of structural elements made of discretely heterogeneous composite materials has been studied in a large number of publications in modern scientific bases and systemically presented in [1]. Among the general issues of workability and reliability of composites, the tasks related to the stability of individual composite structural elements and composite systems [2], in which the influence of physical and mechanical [3, 4], geometric factors [5, 6, 7], generally accepted defined fixing conditions [8, 9] and variables of flexible fixtures [10, 11] and other impact characteristics [12, 13] on the critical force value have been investigated, occupy a due place. The criterion for the effect of the resistance of an elastic medium on the stability of a bar immersed in such a medium is of practical interest. Thus, Tymoshenko S. P. in his classic work "Stability of Bars, Plates and Shells" [14] gives results of research on the stability of a