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# Optimization of Windmill's Layered Composite Blades to reduce Aerodynamic Noise and Use in Construction of "Green" Cities

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**Abstract**

One of the decisive factors in reducing the intensity of energy consumption is the use of energy-saving technologies in construction. The overall strategy for the development of energy efficient buildings starts with search of ways and means to reduce the energy-requirements - optimal use of natural energy resources. The trend of the new millennium is decentralization of power production. Accordingly, each building is regarded as an autonomous power plant. Limitations of using this source of renewable energy (RES), in urban development, such as wind power, are associated primarily with the noise that wind turbines make in the process of use.The article discusses the possibility of using multilayer composite materials in blades of perspective wind turbines and their comparison with peers from other materials.



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## 1. Introduction

- Since the end of the last century, "green" construction became popular, i.e. construction with minimal impact on the environment, which is achieved through:
- effective use of renewable energy and other resources;

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• attention to the maintenance of residents' health and improvement of the workers' efficiency;
• reducing waste, emissions and other environmental impacts.

In countries, where building "green" cities is developing, the national standards are created, international green standards are adapted, which take into account the socio-economic and natural conditions of the country. For example, standards about reasonability of the introduction of such recommendations in the southern regions of Kazakhstan as autonomous electric power generation by wind turbines and solar panels.

The widespread use of wind turbines in the construction of "green" cities is limited by aerodynamic noise that is produced by these turbines' blades during strong winds, causing discomfort to the residents of nearby houses. Constructors of perspective wind turbines see the solution to this problem as a change in the profile and the application of new materials. In the design of blades of wind turbine's fans, there is a transition from the shape, close to the rods with a twist and high aspect ratio, to shapes of the type of plates with low aspect ratio, high twist and flexure. Instead of modern metal alloys, intermetallic compounds, metal matrix composites and ceramic matrix composites begin to be applied [1,5-15]. With the improvement of methods for the calculation of modern wind turbines, geometric characteristics, and aerodynamic and temperature loads of bladed disks and drum become more certain, which makes it possible to apply the numerical methods to determine the strained-deformed state (SDS) of blades. Prospective models of windmill have blades with a large sweep angle, twisted spanwise and curved about the axis of rotation. These blades must work in a very complex and difficult aeromechanical conditions.

Similar designs have been well known, but still there were the lack of means for their calculation and materials for their production. Today, thanks to the emergence of high-speed computers and complex engineering software, as well as the availability of modern composite materials, it is possible to make a more thorough and accurate analysis of advanced windmill blades. Therefore, using the materials obtained in [1-3], has been made a calculation program on computer, that allows numerically determine SDS of blades from composite material (CM).

## 2. Research

A program designed for the study of SDS of naturally spun layered rod construction, which are under the combined effect of tensile forces, bending and twisting moments or under the effect of centrifugal force. Each layer of the studied section of the rod consists of an orthotropic material with 9 independent elastic constants. At that the goal-oriented regulation of general properties of a certain material can be made by selecting the scheme of fibers' laying in separate layer, as well as by placement of the layers with known properties in the cross section. This is achieved by changing the angles $\varphi_i$ between the main directions of material's elastic symmetry in the layer and axes in which SDS of body is investigated. The number of independent elastic constants of the layer's material will generally be equal to 13 [1].

The cross section of the considered rod constructions is arbitrary. The input parameters of the program are the coordinates of the line, which limits a separate arbitrary plane section, usually defined in the working drawings of the project. This line is divided into two parts (conventionally called "back" and "trough"), which is adjacent to the two outer cross-sectional layer. Coordinates of outer surface of mentioned layers are defined. Based on these initial data using a special procedures, the section of arbitrary configuration is divided into individual layers at a defined thickness $t_c$ of monolayer [4]. Thus formed numbers of each layer's beginning and end. Such constructions held for a number of successive sections of the rod (Fig. 1). Since the cross-sectional dimensions may vary along the length of the rod, then the number of layers in each section may be different. This determines the appearance of short layers within the section. Taken from different sections the start and end coordinates of one layer determine the length of the lobe in the current section of the rod.