

LINEAR INTERPOLATION POLYNOMS, TORSION OF A ROD WITH A NON-CIRCULAR CROSS-SECTION

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Introductions. The stages of implementation of the method are considered using the example of obtaining a numerical solution to the problem of twisting a rod with a non-circular cross-section.

Aim. The purpose of the work is to consider the issues of the general theory of twisting of a rod with the presentation of all stages of implementation of the method by obtaining a numerical solution to the problem of twisting a rod with a circular cross-section.

Materials and methods. The problem of twisting a rod with a non-circular cross-section is characterized by the following features - the stiffness matrix is easily calculated, the integrals along the boundary of the area turn to zero due to the definition of the limit values of the calculation function by zero. Also, the problem of twisting a rod with a non-circular cross-section is important for a wide range of problems, such as mechanical problems, field theory problems, etc. The differential equations obtained when considering the problem of twisting a rod with a non-circular cross-section are similar to those describing heat transfer, groundwater flow etc.

According to the theory of twisting of cylindrical rods with an arbitrary cross-section, the shear stresses arising in the body as a result of the action of the torque can be calculated at an arbitrary point according to the appropriate relations that relate these stresses to the stress function. The differential equation for the stress function includes the shear modulus and the twist angle per unit length and is solved taking into account the boundary conditions. After solving the specified differential equation, the value of the torque is calculated. The stress function can be illustrated

by some surface covering the cross section of the rod. The torque is proportional to the volume covered by this surface, and the shear stresses are related to the angles of inclination of the tangents to this surface in the corresponding planes.

The variational statement of the problem of twisting a rod with a non-circular cross-section is reduced to the consideration of some functional, the minimization of which leads to a system of linear equations that is solved after choosing the shape of the cross-section and dividing it into elements.

A well-known and sufficiently clear example of determining the matrix of elements and using it to form a system of linear equations is the problem of a rod with a cross-section in the form of a square when, due to the presence of four axes of symmetry, only the eighth part of the square is considered. In the future, this part of the section is divided into four elements, for which the corresponding interpolation polynomials and the general formula for the stiffness matrix of the element are written. After appropriate mathematical transformations, the final complete system of equations is obtained by algebraic summation of equations for individual elements and determination of nodal values.

In the problem of rod twisting, the important quantities are the derivatives of the stress functions, which are simply related to the shear stresses. The value of these stresses is quite easy to calculate, since the corresponding matrix of gradients for each element is already defined.

The shear stresses are constant in each of the elements because the interpolation polynomials for the elements are taken to be linear along the corresponding axes and it is impossible to obtain variable derivatives of the area of the element.

It is possible to solve this problem and find out the value of stresses in the middle of the rod by increasing the number of elements when breaking down the cross section, by using a triangular element with an increased number of nodes and including square and cubic terms in the interpolation polynomials, or by applying the theory of combined approximation.

When applying linear interpolation polynomials, it is impossible to obtain

gradients as a function of coordinates, so both the gradient and other related quantities are constant within the element. In order to obtain more acceptable values of nodal values, averaging methods or approximation theories are used. The application of the approximation theory allows reducing the problem to the solution of a system of algebraic equations, the order of which coincides with the order of the system that was used to obtain nodal values.

Results and discussion. The stages of implementation of the method are considered on the example of obtaining a numerical solution to the problem of twisting a rod with a non-circular cross-section.

Conclusions. The work deals with the issue of the general theory of twisting of a rod with the presentation of all stages of implementation of the method by obtaining a numerical solution to the problem of twisting a rod with a circular cross-section.

Literature

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