DISCRETIZATION OF THE AREA

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Introductions. The finite element method is to model a spatial continuous object with a set of finite elements. The division of the research area into relevant sub-areas is the initial stage of modeling. The breakdown of the region depends on the available experience and is decisive for the final results of calculations.

Sampling of the object of study is to determine the number, size and shape of the elements used to build a discrete model of the real body. The elements must be small enough to obtain acceptable results in terms of the accuracy of the reproduction of the body shape and the change in the field of the calculated physical quantity, combined with acceptable computational complexity.

Aim. The aim of the work is to review the approaches to sampling the computational domain using the finite element method.

Materials and methods. The variety of forms of objects of the surrounding world determines the need for finite elements of different types when solving problems by the finite element method.

The simplest of all possible elements is one-dimensional. Schematically, it is a segment, although it has a cross section. The cross-sectional area can vary in length, but in many problems it is considered constant. The simplest one-dimensional element has two nodes, one at each end. Elements of a higher order can have three (square) and four (cubic) nodes. A one-dimensional element can be curved, provided that the length of the arc is included in the corresponding equations.

Two main families of elements are used to construct a discrete model of a two-dimensional domain: triangles and quadrilaterals. The sides of the linear elements of each family are straight lines. Square and cubic elements can have both rectilinear and curvilinear sides, or both. The ability to model curved boundaries is achieved by adding nodes in the middle of the sides of the elements.

The most commonly used three-dimensional elements are the tetrahedron and the parallelepiped. In both cases, the linear elements are bounded by rectilinear sides. Elements of a higher order may be limited by curved surfaces.

The process of sampling is conditionally divided into two stages - the division of the body into elements and the numbering of elements and nodes. The second stage is simple in terms of execution methods, but is complicated by the circumstances of computational efficiency.

The sampling of a one-dimensional body is trivial and consists in dividing the segment into shorter sections.

In the case of discretization of a two-dimensional region, the best types of finite elements are triangles. Such elements are the simplest and most universal in terms of the shape of the boundary of the sampling area and analytical relations in the calculation equations. When dividing any two-dimensional area into elements, the body is first divided into quadrilateral and triangular parts, which are further divided into triangles. The boundaries between the parts should be where the geometry or properties of the material change, the applied load or external restrictions. If the triangular part of the simulation area is curvilinear, then the curvilinear boundaries of the elements are replaced by straight segments. Quadrangular zones are divided into elements by connecting nodes on opposite sides. The intersection of the lines determines the internal nodes. Internal quadrilaterals can be considered as elements. Such elements can be divided into triangles by drawing a short diagonal in each inner quadrilateral. This approach is desirable because it allows you to get elements that are close in shape to an equilateral triangle, which, in turn, allows you to get more accurate results, compared with the use of long narrow triangles.

The number of nodes on adjacent sides of the quadrilateral may be different, but on opposite sides the number of nodes must be the same, except in cases of grinding or enlarging the lattice. To obtain elements of different sizes, the distance between the boundary nodes may be different.

The triangular and quadrilateral parts of the simulation area may have a common boundary. The number of nodes and their relative position at this boundary for both parts must match. This circumstance is determined by the need to maintain the continuity of the considered values along the total boundary of the elements.

Uniform breakdown with elements of the same shape and size is usually not performed. This is due to the unevenness of the fields of the studied physical quantities with the corresponding gradients and the presence of concentration zones. The ability to resize elements is an essential positive feature of the finite element method, which allows you to combine a fairly high accuracy of calculations with acceptable computational complexity. To change the size of the elements, it is advisable to use quadrangular subdomains with different numbers of nodes on opposite sides. It is also possible to place two nodes on one side against every three nodes on the opposite.

The efficiency of calculations is significantly affected by the numbering of nodes. This is due to the fact that the use of the finite element method leads to a system of linear algebraic equations, a significant number of coefficients of which is zero. In this matrix of system coefficients, all non-zero coefficients and some of the zero coefficients are in the band along the main diagonal. The width of this band is determined by the largest difference in the numbers of nodes within one element. All odds outside this band are zero. The computing program uses only those matrix coefficients that are located within the specified band. Reducing the bandwidth leads to a reduction in computational volumes and an increase in computational efficiency with a reduction in computational time.

Results and discussion. The paper considers typical types of elements used in the finite element method. The issue of numbering of nodes of finite elements is considered which determines the scope of calculations and increase computational efficiency with a reduction in computational time.

Conclusions. The finite element method is an effective numerical method for solving engineering and physical problems, and the scope covers a wide range of problems.

Literature

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