A METHOD FOR CONSTRUCTING CALCULATION MESHES IN TWO-DIMENSIONAL REGIONS WITH SEPARATION OF INTERIOR CONTACT INTERFACES*

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Abstract. *A method is suggested for constructing Lagrangian calculation meshes in two-dimensional regions with interior contact interfaces. The method is based on a simple geometrical approach to the construction of calculation meshes in regions with complex configuration and the procedure of reconstructing meshes for the explicit separation of interior curvilinear contact interfaces by producing a continuous sequence of "collapsed" cells. The constructed meshes are meant for solving contact problems in dynamics of deformable solids with complex boundary conditions (slipping with friction, separation, and restoration of contact). The suggested method for separating contact boundaries is simple in the programming and sufficiently universal, and it does not require large computing time expenditures. The elaborated meshes reconstruction algorithms can be used for creating algorithms for constructing destruction surfaces in a solid that are necessary when solving dynamic elastoplastic problems.*

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1 INTRODUCTION

In the solution of spatial problems of dynamics of deformable solids use is made of Lagrangian calculation meshes that move and are deformed together with the medium, which results in their substantial distortion in the region of strong deformation. This poses the well-known difficulties when performing calculations. One of the ways of overcoming these difficulties consists in periodic reconstruction of the meshes for their improvement. Depending on the specificity of the problem, this mesh reconstruction can be carried out in some zones of the calculation region or in the whole calculation region. Therefore it is important to be able to construct, at each given instant of time, a mesh that provides the best covering of the calculation region in the above-mentioned sense. As to the bodies with interior curvilinear contact interfaces (boundaries between the layers, cavities filled with a different medium, etc.), in this case the construction of a unified calculation mesh providing the best covering of the region and separating out the contact surfaces presents a problem even when the boundary of the body has a simple configuration. In the present paper a method is suggested for separating out the interior contact boundaries in two-dimensional regions covered by quadrangular meshes that is based on a procedure of local mesh reconstruction. The ideas of the procedure are close to those used in [1,2] for an explicit separation of destruction surfaces in solids. The constructed meshes are meant for solving contact problems in dynamics of deformable media complex boundary conditions (slipping with friction, separation, and restoration of contact) [3].

2 CONSTRUCTING A CALCULATION MESH IN A REGION WITHOUT SEPARATING OUT THE INTERIOR CONTACT BOUNDARIES

Let a contact surface inside a calculation region G be a piecewise smooth curve without self-intersection. To separate out the contact surface the following algorithm is suggested for constructing a unified calculation mesh in the region.

- First, a unified mesh is constructed without separating out the contact surfaces.
- Second, a way of passing across the contact surfaces over the network is determined.
- Third, the mesh is reconstructed in the neighborhoods of the contact surfaces so that the contact surfaces are a continuous sequence of "collapsed" cells in which every subsequent cell and the foregoing cell have either a common side or a common vertex. And the parts of the region separated by the contact surface must consist only of entire cells.

To realize the first stage of the algorithm, a geometrical approach to constructing calculation meshes suggested in [4] is used.

3 DETERMINING THE WAY OF PASSING ACROSS THE CONTACT SURFACE OVER THE MESH

Introduce a coordinate system OZR. Denote by $(Z1(i,j), R1(i,j))$ the coordinates of the points of intersection of the curve with the mesh that lie on the line segments with end points (i,j) and $(i+1,j)$, i.e., on the "horizontal" sides of the cells. The coordinates of the points of intersection lying on the line segments with points (i,j) and $(i,j+1)$, i.e., on the "vertical" sides of the cells, are denoted $(Z2(i,j), R2(i,j))$. We call them points of type I and type II.

It is also convenient to denote the "horizontal" and "vertical" sides of the cells that are intersected by the curve as $(Z1(i, j), R1(i, j))$ and $(Z2(i, j), R2(i, j))$ on condition that all these pairs of numbers are given the same values (W, V) such that the coordinates of the points of intersection can be no means assume them.

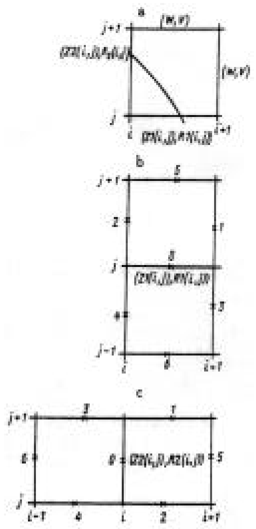

Figure 1: Determine the way of passing near contact boundary passing through

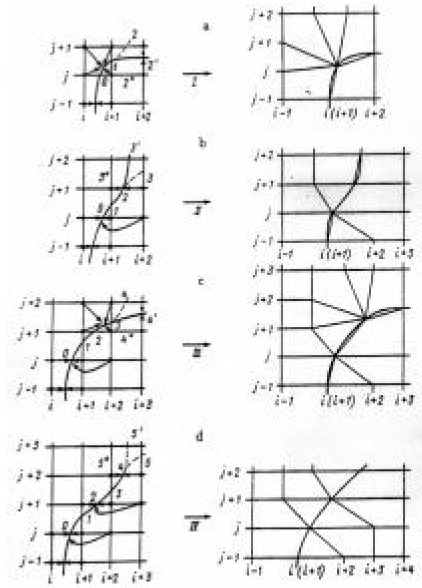

Figure 3: All possible variants of mesh reconstruction across the contact surface over the mesh stepped sections

Hence, with each side of any of the calculation cells a pair of numbers $(Z1(i, j), R1(i, j))$ or $(Z2(i, j), R2(i, j))$ is associated, which has either the value of the coordinates of the point of intersection of this side with the curve or the value (W, V) (Fig. 1a). For each of the determined points of intersection of type I the role of the neighboring point of intersection can be played by one of the points 1-6 (Fig. 1b). A similar situation takes place for points of type II (Fig. 1c). A point of intersection of the curve and the mesh coinciding with a cell vertex will be related to the type of the foregoing point. When arriving at the point $(Z1(i, j), R1(i, j))$ or $(Z2(i, j), R2(i, j))$ in the consecutive motion along the curve, we determine the next point of intersection by comparing the coordinates of each of the points 1-6 with the values (W, V).

4 RECONSTRUCTING THE MESH

It is easy to reconstruct the mesh on those sections where the passes, over a series of cells forming a strip, "parallel" to the sides of the strip (Fig. 2). All the points of intersection of the curve with the mesh on such sections belong to the same type, for example, type II (Fig. 2).

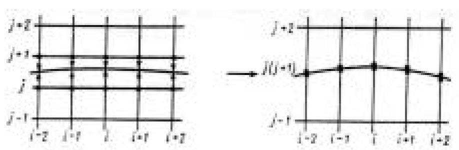

Figure 2: Reconstructing the mesh on cells sections, forming a strip

The curve intersects strips and stepped sections. Here a stepped section is defined as a sequence of cells intersected by an interior curve containing no two consecutive points of intersection of the same type, i.e., after each point of intersection of type I a point of intersection of type II must follow and vice versa. All possible variants of mesh reconstruction near contact boundary, passing through stepped sections, present on Fig. 3.

The transfer of the calculation nodes to the interior curve in its neighborhood results in mesh rarefaction. To make the network more uniform, we again use the iterative process in [4] but fix those vertices, which, as a result of reconstruction, fall on the contact curve.

5 AN EXAMPLE OF MESH CONSTRUCTION

As an example, we consider the mesh construction in a two-dimensional region meant for calculating axisymmetrical deformation of a solid of revolution, namely a thick-walled shell of revolution of variable thickness containing a filler. The influence between the shell and the filler serves as the contact surface that must be separated out as a result of the application of the algorithm of mesh reconstruction. Fig. 4a represents the construction of a unified calculation mesh without separating out the contact boundary, and shown in Fig. 4b is the final version of a mesh with separated contact boundary between the shell and the filler, which is a piecewise smooth curve consisting of rectilinear and ogival sections.

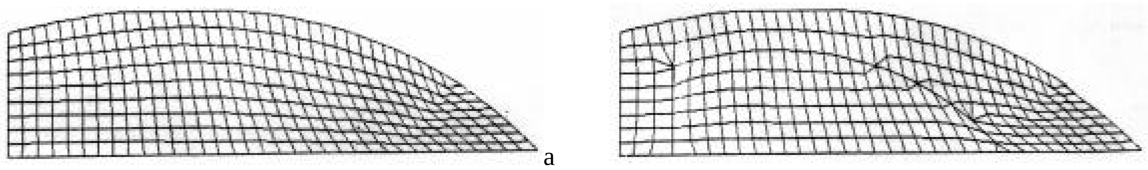
a b

Figure 4: An example of mesh construction

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