NEW FINITE ELEMENT METHOD BASED ON REFORMULATION OF DISCRETE ELEMENT METHOD

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It is known that a discrete element method (DEM) is an efficient numerical computation method for failure problems, although it is not so popular as a finite element method (FEM) in engineering communities. This is mainly because DEM adopts block-spring modeling for a deformable body. Although it is simple, block spring modeling is not used since continuum modeling has been established for a deformable body.

The authors review the formulation of DEM in the framework of continuum mechanics, instead of treating it as a method for block-spring modeling. It is found out that DEM can be regarded as a particular form of FEM which uses characteristic functions as interpolation or shape functions. The characteristic functions are used for blocks which do not overlap each other. Thus, failure is easily treated with, as cutting the connection of the characteristic functions.

Based on the above reformation of DEM, the authors are proposing FEM that uses the characteristic functions [1], called FEM-β in this presentation. The formulation of FEM-β is shown for two-dimensional elastic body as the simplest example. Some properties of FEM-β, such as the speed of convergence and the accuracy of computing the solutions with singularities are explained. Emphasis is put on the fact that is FEM-β for continuum modeling, not for block-spring modeling that DEM is applied to.

In particular, it is shown that when the discretization is made by using the Voronoi diagram, the global stiffness matrix of FEM-β coincides with the one of the FEM with triangular elements. The global stiffness matrix, however, changes in a quite different manner in analyzing cracks which propagate in the body as load increases, since FEM-β deals with the failure as the loss of the connection of two blocks which are separated by the cracks. This treatment is the same as DEM which cut the spring between two rigid-bodies.

While it is a particular form of FEM, FEM-β is regarded as an improved form of DEM in the sense that the spring constants are rigorously determined in terms of the material properties of continuum modeling and the configurations of blocks. In other words, FEM-β reduces a problem of continuum modeling to another problem of the equivalent block-spring modeling. Also, it is explained that FEM-β is a numerical method for boundary (or initial) value problems of differential equations by using non-overlapping characteristic functions, which is suitable to solve problems with moving boundaries.

References

[1] K. Iwai, K. Oguni and M. Hori , “Proposal of new analysis method for fracture phenomena,” *Journal of Applied Mechanics, JSCE,* v. 5 (to be submitted).