POSSIBILITIES OF A LAGRANGIAN NUMERICAL METHOD FOR FLUID DYNAMICS IN CIVIL ENGINEERING

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Abstract

Civil Engineering was one of the first fields in which the Finite Element Method (FEM) was used in practical applications. The calculation of complex structures is being done every day more commonly with this method.

However, the use of the Finite Element is not limited to this field, and can be very useful for electromagnetism, wave propagation, flow inside porous medium, convection-diffusion problems or even fluid dynamics. In particular, the Meshless Finite Element Method (MFEM), similar to the FEM, has begun being used for, mainly, modelling fluid movement.

Dam, a program developed at CIMNE these last years, in collaboration with CIMEC, uses the MFEM for the equations of fluid mechanics in a lagrangian formulation, and it appears as a trial to solve the problems related with other formulations. As an especially new feature, this program calculates a new mesh at every time step.

The main advantage of this lagrangian formulation is that convective terms do not appear in the governing equations, and they are responsible of a lot of typical problems when an eulerian formulation is used. On the other hand, remeshing at every time step allows the method to raise big deformation problems naturally, spending little time in the meshing process, which is especially profitable in 3D cases.

The fact that it is unknown whether Dam provides good results similar to reality or not has led to make this minor thesis, whose object is to evaluate the possibility of using it as a calculation tool for the civil engineer.

This way, the calculation and meshing algorithm are presented with a certain detail, for a better understanding of what are the practical advantages of the used method.

Next, some results given by Dam on some types of problem are analysed, comparing them to other experimental or analytic results to the same problems. The study of the velocity field reveals a great similarity between the results given by Dam and the analytic ones extracted from the linear wave theory, and the pressure field obtained on the hydrostatic case exactly is the analytic one, linear with depth.

When dynamic pressure is strongly present, it becomes difficult to find analytic expressions, which give good and real results. That’s why it was chosen to compare Dam to experimental results obtained in a test channel (CIEM, UPC) by pressure sensors. The results are similar, but some specialized treatment is required on data.

Also, a set of different examples is included, showing the various types of problems, which Dam can deal with, simulating some boundary conditions and common situations in Civil Engineering.

Finally, a chapter is spent on real application of the program to a real example of engineering: the study of the impact of a wave on a vertical breakwater. This chapter was done in order to make evident the easy use of Dam when it is chosen.

All this lets say that Dam is really useful for the civil engineer, thanks to its adaptability and good results, but it is still necessary a certain development of the program to achieve reliability.