DYNAMIC RESPONSE OF PRESSURE VESSELS IN THE NON-LINEAR RANGE TO IMPULSIVE LOADING

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SUMMARY

The paper describes the application of the finite element method to the solution of dynamic transient problems associated with pressure vessels. Isoparametric elements with a quadratic shape and displacement variation are employed in solution and both two and three dimensional situations are considered.

The transient response is modelled by use of an explicit time stepping scheme and a central finite difference algorithm is adopted. For an explicit formulation a diagonal mass matrix is essential and a special procedure, applicable to isoparametric elements, is employed for diagonal lumping of the mass terms. Limits are provided for the critical time step length.

The effects of three important non-linearities are considered. Firstly easto-plastic behaviour of the material is permitted and several yield criteria are included. The second non-linear phenomenon studied is that arising from gross geometrical deformations. Here the deflections of the structure are allowed to become large subject to small strain elastic material behaviour. The combined effect of both non-linearities is also treated.

The above numerical models are mainly applicable to steel structures. On the other hand, the main source of non-linearity in concrete structure is due to tensile cracking of the concrete. A combined Mohr Coulomb/Limited Tensile Strength model is presented for the study of impact loading of concrete pressure vessels in the collapse range. Steel components obeying classical plasticity laws can also be included.

Finally application of isoparametric elements in solid/fluid interaction situations is indicated.

The computational techniques described are illustrated by a wide range of numerical examples and the method is shown to be capable of solving economically many problems of dynamic or catastrophic nature which can occur in such structures as nuclear reactors, containment vessels, etc. Wherever possible, comparison is made with results obtained from other sources.