

THE ANALYSIS OF DYNAMICALLY LOADED NON-LINEAR STRUCTURES

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SUMMARY

Structures which can behave in a non-linear manner occur quite commonly in practice. For example, this may be due to cracking in reinforced or prestressed concrete structures or to some or all of the components of the structure passing the elastic yield point. In the analysis of such structures an iterative solution is essential. Dynamic loading may be due to a variety of causes; missile impact, blast effects, wave loading or earthquakes for example. Loads are in these cases changing with time and this must also be catered for in the analysis.

The method of Dynamic Relaxation is most convenient for the analysis of non-linear structures as it is essentially an iterative process. Both material properties and loadings can be changed quite easily at each iteration. The fundamental equations of the method are comparatively simple and a wide choice of boundary conditions is available, so that the mathematical model can be a good representation of the physical structure. A previous paper has shown how cracks are easily and completely calculated (SMIRT-3 Paper H 4/1). For the dynamic loading case the varying pattern of stresses and deflections can be computed correctly at each iteration and may be printed out as often as desired.

The method has been used to analyse a model of a proposed prestressed concrete containment vessel (PCCV) for a sodium-cooled fast breeder reactor. This application required minimal changes to the program PV2 which was originally designed for static loads on axisymmetric structures. One of the design requirements for the PCCV is that it should be able to withstand the high transient pressures which could be produced by a reactor accident condition. Small models, representing the containment vessel to about 1/50th scale, have been made and tested. These were partly filled with water and loaded internally by detonating explosive charges. Increasing charges were used in successive tests up to a maximum which represented an energy release of 15GJ in the prototype vessel. Internal pressures at selected positions and external deflections were read continuously during the tests.

Prior to the tests the model was analysed using predicted values of the pressure time variations at individual parts of the inside surface which had been calculated by the ASTARTE program.

The analyses, using PV2, were arranged to print out stresses, deflections and crack patterns at suitable time intervals during and after the pressure excursions, up to 3500 microseconds.

Experimental results show good correlation with values predicted from the computer programs as far as peak pressures, times of maximum deflections and crack patterns are concerned. Results and graphs in the paper compare theory with experiment.

The PV2 program has also been used to analyse the non-linear behaviour of a reinforced concrete containment structure due to aircraft impact. Allowance was made for the non-linear behaviour of structure, concrete and reinforcement.