NON-LINEAR DYNAMIC RELAXATION AND ITS APPLICATION TO PRESSURE VESSEL PROBLEMS

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SUMMARY

The application of Dynamic Relaxation to the elastic analysis of concrete pressure vessels has been an accepted method for the last decade or more. This paper shows how the normal formulation of dynamic relaxation can be easily modified to allow for a number of non-linearities in all the constituent parts of a prestressed concrete pressure vessel.

The non-linear dynamic relaxation programs employed are at present under continuous development and the latest state of the art is more fully explained in the work of Carlton and Bedi in their study of aircraft impact on containment structures. Initially tensile cracking was incorporated in only the directions of the orthogonal axis system and in many instances gave acceptable results for thick cylindrical pressure vessels. Later additions allowed cracking in any direction with the structure being considered locally as an orthotropic material. The importance of including bonded reinforcement was studied together with yield and failure of the unbonded prestress cables. Loss of aggregate interlock can greatly modify structural behaviour, as can non-linear compressive properties. The latter was studied in various ways including simple non-linear stress-strains relationships and various yield criteria.

Various formulations were tested out on pressure vessel and end cap problems that had been studied analytically and by experiment wherever possible. The studies include experimental tests carried out by Taylor Woodrow and as yet unpublished. These show the effect of such items as bonded reinforcement on the level and mode of failure and indicate the accuracy of the various forms of analysis. This last point is of importance in minimising the computer time required to achieve acceptable results.

A more detailed study was made of certain components of a prestressed concrete pressure vessel designed to withstand very high pressures (69 N/mm^2), previously analysed elasto-plastically by the MARC finite element system. An important consideration discussed is the use of such non-linear analysis methods for design purposes, and especially their application in assessing the concrete's acceptability under working conditions.

The paper shows that not only can highly complex non-linear forms of structural behaviour be easily predicted but that useful and necessary information can be supplied to the designer very much more quickly than by physical experimentation.