ULTIMATE STRENGTH DESIGN OF PRESTRESSED CONCRETE REACTOR VESSELS

C. MEYER, B.I. GOLDMAN

Stone & Webster Engineering Corporation, Boston, Massachusetts 02107, U.S.A.

SUMMARY

Current design philosophy for PCRVs requires that the structures behave elastically under all possible combinations of design loads; that they fail gradually under pressure overload; and that an adequate safety margin against structural failure exists, which is measured as the ratio between ultimate load capacity and maximum coolant pressure.

Because of their lack of warning, sudden shear type failures are generally undesirable. Therefore, the specification of two separate safety factors has been suggested, one for the bending failure of the vessel and a larger one for the shear failure of the top head. For the determination of ultimate load capacities of PCRVs, earlier investigators have modified the yield line concept developed for the ultimate strength analysis of slabs and applied it to reactor vessels. Having assumed certain crack configurations, certain free geometric parameters were varied to obtain the minimum pressure that causes failure.

For the work reported in this paper, a non-linear three-dimensional finite element program (described in detail in a separate paper in this conference) was used to analyze a PCRV for a variety of loading conditions that may occur during its design life. In order to determine the ultimate pressure which causes bending failure, the vessel was analyzed for monotonically increasing internal pressure up to failure, which was defined as a combination of limits on overall displacements, concrete crack widths and liner cracks. With deterministic yield criteria and cracking laws built into the program, it was possible to uniquely determine the ultimate pressure in a single analysis.

Similarly, to arrive at a pressure resulting in shear failure, the top head of the PCRV was modeled separately in a way which would preclude premature failure in bending. Upon monotonically increasing the pressure loading, again a deterministic cracking configuration developed which ultimately led to the required failure load, during a single analysis course.

A comparison between the results of this analysis and those obtained through the traditional iterative procedures showed satisfactory agreement.

In a companion paper, the theory on which the computer program is based is described at length, as well as its application to the analysis of PCRVs for design loads. It is the purpose of the present paper to show that it may be used for the determination of safety factors against overloads, also. Therefore, such a general analysis program may serve to satisfy all structural analysis needs associated with the final analysis of PCRVs.