COLLAPSE MECHANISMS OF LOCALLY LOADED REINFORCED CONCRETE SHELLS

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Abstract

Experiments are presented on the local lateral loading of steel-reinforced micro-concrete hollow cylinders supported by heavily reinforced end diaphragms. The tests exhibit three distinct ultimate modes of failure; global flexural beam collapse, more localised ovalisation, and local punching shear/flexure interaction.

The theoretical work concentrates on the behaviour of locally loaded shells, wide beams and arches in plane strain, and axisymmetric and domes. Families of kinematically admissible symmetrical mechanisms are developed for each case and analysed using the upper bound theorem of plasticity assuming rigid plastic material behaviour, the modified Mohr-Coulomb failure criterion for concrete and the associated flow law.

The concept of the shear/flexure interactive failure zone is developed to provide a range of solutions from pure punching shear to pure flexural failure. Calculation of the internal energy dissipation in the narrow interactive zone is facilitated by consideration of the instantaneous centre of relative rotation between the rigid blocks surrounding the zone. The optimum position of the interactive zone is found by variational calculus for a given instantaneous centre and boundary conditions. It is explicitly defined for beams and arches, but numerical analysis is required for the axisymmetric cases. The remaining dissipation terms are substituted into the work equation and provide the upper bound load for any chosen mechanism. By placing the instantaneous centre in different positions, the regimes of ultimate behaviour are explored for certain pertinent cases of beams, arches, slabs and domes. Particular consideration is given to the effect of shell dimensions, material properties and support and loading conditions.

Comparisons are made between the present theory, simpler theory and experimental data on beams, arches, slabs and domes. The insight provided by these comparisons is used to

illuminate the more complicated ultimate behaviour of the locally loaded cylinders investigated in the present experiments.