FINITE ELEMENT ANALYSIS OF MEMBRANE ACTION IN REINFORCED CONCRETE SLABS

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Abstract

Membrane action in reinforced concrete slabs is a material as well as a geometric non-linear problem, for which the finite element method can be adopted. This possibility is still being investigated. An investigation is presented in the thesis.

A comparison of methods of analysing geometric non-linearity in plane frameworks shows that using the average, rather than the local, strains in the finite elements gives more accurate results, demonstrated when an aluminium toggle tested elsewhere was analysed. A material non-linear procedure is developed; it computes accurately the current stiffness matrix of a reinforced concrete structure, from its material properties, current stiffness matrix of a reinforced concrete structure, from its material properties, as the analysis progresses. This procedure gave satisfactory results when 3 reinforced concrete beams tested by the author and a reinforced concrete frame tested by another research student were analysed. Both the material and the geometric non-linear procedures were used with the developed displacement control method, which allows total nodal displacements to be used during iterations.

The procedures developed for geometric and material non-linearities were combined in order to analyse membrane action in 5 reinforced concrete one-way slabs, tested by the author. The behaviour of these slabs shows non-linearities due to the instability of the compressive dome formed in the slabs, the crushing of concrete, and the fracture of reinforcement. The developed program did well in predicting these effects.

The program was then extended to two-way rectangular slabs and used to analyse 4 slabs tested by another author. Reasonable agreement was again obtained. A total of 243 slab examples was analysed and the results were used to derive equations for determining the peak load and the corresponding deflection at the compression failure of an isotropically reinforced

rectangular concrete slab clamped along all edges. The geometric and the material properties of the slab normally known are the parameters required to use these equations. When these equations were tested against the experimental results for 20 slabs published by 3 different authors, the average ratio of experimental to predicted, was 0.84, with a standard deviation of 0.13, for the loads, and 2.11, with a standard deviation of 0.32, for the deflections. The prediction for the deflections is not very good probably because of the general high stiffness of finite element solutions and/ or because of the axial movements that might have occurred at the supports during the experiments. Further work is required to take flexibility of supports into consideration in these equations.