THE ULTIMATE BENDING STRENGTH OF REINFORCED CONCRETE SLABS

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Abstract

Experiments are described which provide direct evidence on the criterion of failure under different combinations of stress resultants, for a concrete slab element reinforced with mild steel, when shear forces normal to the slab are not significant. With practical percentages of reinforcement, failure can often be described as yielding under closely constant stress resultants, and the criterion of failure can then be used as a yield criterion in the analysis of slabs under short-term loading, by any of the methods of plasticity theory, including yield line analysis.

The stress/strain properties of a layer of parallel steel bars in uniaxial strain at different angles to the bar direction, which determine the stress resultants developed on a yield line, are obtained from a series of tests in slabs in uniaxial curvature. A second series of tests on rhomboid slabs is used to investigate the criterion of yield, under biaxial pure moments, slabs with equal orthogonal reinforcement.

A method is developed of using plasticity theory, and simple assumptions, justified by the experimental results, about the properties of the steel and the concrete, to obtain the yield criterion for a slab element under general combinations of bending moments and membrane forces. The stress resultants corresponding to given plastic strain-rates can be found, and equations are presented which allow the ultimate value of a given combination of stress resultants to be closely approximated.

Some implications of the yield criterion thus found, for conventional yield-line theory, are investigated, particularly in slabs without lateral restraint at the edges. A theoretical justification is given for Johansen's equilibrium method of finding the least upper bound for a family of assumed collapse mechanisms are considered, and some extensions of the method are developed.

The design of slabs for minimum reinforcement is investigated, using the experimental material properties. General sufficient conditions for minimum reinforcement are established, and a number of solutions are given, for circular and rectangular slabs and without lateral edge restraint.