Modelling the collapse behaviour of reinforced concrete slabs

Andrew Jackson

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This thesis presents a new method for predicting the load at which a general reinforced concrete slab will collapse in flexure. The new method is referred to as 'combined lower and upper bound plastic analysis' and is particularly suited to the assessment of existing concrete slabs such as bridges. Engineers often use conservative analysis techniques to assess existing slabs and therefore sometimes recommend the strengthening or replacement of structures which are actually safe; use of the new method could avoid the cost and disruption associated with this work. The new method uses plasticity theory but it overcomes many of the difficulties that restrict the application of previous plastic techniques.

The new technique consists of a lower bound method and an upper bound method. The lower bound method uses an equilibrium mesh with mathematical programming and iterative refinement techniques. Unlike many previous methods, it rigorously applies the lower bound theorem of plasticity, so it is guaranteed to produce a safe underestimate of the theoretical plastic collapse load. It can be applied to real slabs with complicated geometries, loads and reinforcement layouts.

The upper bound method uses the results of the lower bound method to help an engineer identify a suitable approximate collapse mechanism. This mechanism is then optimised and used to identify an upper bound to the collapse load.

When applied to a range of example slabs, combined lower and upper bound plastic analysis consistently produces lower and upper bounds to the collapse load that are separated by a few percent, showing that they are highly accurate. Unlike other advanced methods, it produces simple results that engineers can easily check. The new method produces good predictions of collapse loads measured in laboratory experiments, although care must be taken to ensure that it is only applied to cases where the assumptions made by plastic flexural analysis are valid.