OPTIMAL FIBRE-REINFORCED PLATES: WITH SPECIAL REFERENCE TO REINFORCED CONCRETE

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Abstract

For the absolute minimum weight design of fibre reinforced plates, the current state of knowledge is reviewed, with emphasis on analytical procedures.

For both plastic and elastic structural materials, the optimisation problem for a sandwich plate is presented in general terms, and in particular it is shown that slope discontinuities in the deflected shape of the plate may occur in certain circumstances. A necessary condition for optimality is derived which agrees with previous results. For the case of no slope discontinuities, this condition is also sufficient. For fibre reinforced plates, this condition is also sufficient. For fibre reinforced plates, implications of the optimality conditions are examined, and it is shown that for a constant thickness plate the optimality condition reduces to an earlier condition obtained b Morley (1966), but with less restriction on the continuity of slope of the deflected plate surface.

It is shown that the optimal fibre layout may consist of straight fibres and that for simply-connected boundaries and kinematically determinate plates the optimal layout may be obtained by means of the “loadpath” technique.

A large number of problems are examined using this device and a number of new solutions presented. Aspects examined include clamped boundaries, mixed boundaries, circular slabs, continuous slabs, holes in slabs, thickness variation and slabs with edge beams. Some tabulated data is presented for the latter.

The “moment-volume” as a measure of minimum weight is used to compare a number of optimal designs to the corresponding homogeneous isotropic elastic solutions.

A simple example for the design of beams and plates under alternate loading systems is also presented.

Some remarks are also made on design for crack control in relation to optimal design of idealised reinforced concrete, and the implications of the idealisations are also discussed.

Tests on 6 slabs, 3 designed on the basis of the optimisation theory, and 3 on the basis of yieldline analysis, are also described. The slabs have clamped edges, and also edge beams in two cases.

It is found that despite the use of very thin slabs, the behaviour in terms of cracking and deflections was closely similar for both optimal and yieldline designs.