COLLAPSE OF CONCRETE BOX GIRDERS INVOLVING DISTORTION OF THE CROSS-SECTION

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Abstract

A yield criterion, which is suitable for determining the moments and membrane forces on a generalised yield line in a concrete slab, reinforced with mild steel, is derived in a parametric form, based on simple assumed properties for steel and concrete. The generalised yield lines considered allow for in-plane shear displacements in addition to the transverse bending and displacement normal to the yield-line customarily associated with yield-line theory. Simple functions, which can be employed as yield criteria when using plasticity theory in the analysis of slabs under short-term loading, are presented as close approximations to the parametric yield criterion. The theoretical expressions are compared with the available experimental evidence of reinforced concrete slab failure under combined stress resultants.

Possible failure modes for single cell and multi-cell, single-span and continuous, concrete box girders, involving distortion of the cross-section, are investigated. Two classes of distortion mechanism are considered; one class is determined by the presence, the other class by the absence, of in-plane shear strain in the webs and flanges of a box girder at collapse. The mechanisms are used in the calculation of upper bounds on the collapse loads of concrete box girder. Generalised yield lines occurs one type of mechanism and the derived yield criterion us utilised in the associated upper bound calculation.

Ultimate load tests, using eccentric loads, on three, simply supported, two-cell concrete box girder, and on one, single-cell box of a multi-cell girder, are described in detail. Comparisons between upper bound predictions, and results obtained from the experiments and tests reported elsewhere, are made. The suitability of rigid-plastic theory for estimating the collapse loads of concrete box girders is discussed, and observations about some aspects of concrete box girder design are made.