Journal of Sound and Vibration (2002) **250**(4), 649–673
doi:10.1006/jsvi.2001.3957, available online at http://www.idealibrary.com on IDEAL®

FORCED VIBRATIONS OF TRIPLY COUPLED, PERIODICALLY AND ELASTICALLY SUPPORTED, FINITE, OPEN-SECTION CHANNELS

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(*Received* 1 *June* 2000, *and in final form* 24 *July* 2001)

An exact analytical method is presented for the analysis of forced vibrations of uniform, open-section, single- and multi-bay periodic channels. The centre of gravity and the shear centre of the channel cross-sections do not coincide, and hence the flexural vibrations in two mutually perpendicular directions and the torsional vibrations are all coupled. The ends of the channels and the periodic intermediate supports are modelled with springs having finite flexural and torsional stiffnesses. Single-point force excitation has been considered throughout the study, although the developed method is also capable of dealing with multi-point excitation. The channels are assumed to be of Euler–Bernoulli type beams. The study also takes the effects of cross-sectional warping into consideration. The developed method is suitable for structurally damped analysis and in addition to yielding forced vibration characteristics; it also straightforwardly reveals the free vibration properties like the mode shapes.

1. INTRODUCTION

If the centre of gravity and the shear centre of an open-section channel cross-section do not coincide, the flexural vibrations are inevitably coupled with the torsional vibrations. The stiffener, being an important element of aeronautical structures, is a typical structure, which undergoes such a motion.

Although studies involving finite element methods are numerous in literature, Gere and Lin [1] and Lin [2] presented some of the first analytical works in this field and obtained the coupled, but free vibration characteristics of uniform, open-section channels using the Rayleigh–Ritz method. The effectivenesses of various beam theories in the solution of beams having coupled torsion and bending were compared by Bishop *et al.* [3]. Dokumacı [4] developed an exact analytical model for the determination of coupled vibrations of open-section channels, which were symmetric with respect to an axis, though the warping was not admitted. Bishop *et al.* [5] then allowed warping in Dokumacı's theory and investigated the same type of Euler–Bernoulli beams of open cross-section. In all of these works, only the free vibration characteristics and the classical end boundary conditions were studied. Freiberg developed a numerical method for the solution of coupled beam

0022-460X/02/090649 + 25 $35.00/0