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THE HARMONIC RESPONSE OF UNIFORM BEAMS ON MULTIPLE LINEAR SUPPORTS: A FLEXURAL WAVE ANALYSIS

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A wave approach is developed for the exact analysis of the harmonic response of uniform finite beams on multiple supports. The beam may be excited by single or multi-point harmonic forces or moments; its supports may have general linear characteristics which may include displacement–rotation coupling. Use is made of the harmonic response function for an infinite beam subjected to a single-point harmonic force or moment. The unknowns of the finite beam problem are the support reaction forces/moments and the magnitudes of four waves reflected from the ends of the beam. Equations are presented for the response of a single-bay beam with various support conditions and subjected to single-point harmonic excitation. The same equations, but with the simple addition of further straightforward terms on the right-hand side, are used for multi-point excitation. The effects of damping are easily incorporated. Equations for multi-supported beams are also presented together with illustrative computed frequency-response curves. Natural frequencies have been calculated by finding resonance frequencies of very lightly damped beams. These compare impeccably with the results of other investigators.

1. INTRODUCTION

Free and forced harmonic vibrations of simple uniform beams have long been analyzed by a variety of methods. These began with the direct (real) solution of the differential equation of motion [1], from which receptance [2] and transfer matrix methods [3] were derived. Approximate energy methods now dominate the scene, with many different finite element packages being available to perform the calculations.

In the days before computers, calculations of the vibration of complicated beam systems could be performed in practice only by using real arithmetic. This inhibited the development of any method which depended essentially upon a complex formulation and arithmetic. Under this constraint, calculations were carried out in terms of real modes of vibration (which could be found only with considerable difficulty) or in terms of real receptances, etc. (see reference [2]). Calculations for beams on many supports presented considerable difficulty and simplifying assumptions had to be made to overcome them:

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