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THE RESPONSE OF INFINITE PERIODIC BEAMS TO POINT HARMONIC FORCES: A FLEXURAL WAVE ANALYSIS

D. J. MEAD

Department of Aeronautics and Astronautics, University of Southampton, Southampton, SO9 5NH, England

AND

Y. YAMAN†

Department of Aeronautical Engineering, Middle East Technical University, Ankara, Turkey

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An exact analysis is presented of the vibration response of an infinite beam on periodic supports, subjected to a transverse harmonic point force. The supports must all be the same and can be simply supported or be generally linear with elastic, inertial and dissipative properties. The total response is found as the sum of the flexural wave fields generated by the applied force and the infinite number of support reaction forces and moments. The concept of phased arrays of forces and moments is used to sum the support-generated wave fields. This utilizes the propagation constants of free-wave motion in the periodic beam. Equations for either four, six or eight of the unknown complex reactions (depending on the nature of the supports) are set up and solved numerically. This finite number is sufficient to permit the calculation of the beam displacement at any point and of all the other reactions. Some computed values of the beam direct receptance are presented to demonstrate its variation with forcing frequency, the effect of the location of the excitation force and the effect of changing the elastic properties of the supports.

1. INTRODUCTION

Many components of engineering structures are constructed in a spatially periodic form and consist, in effect, of an assembly of identical components, joined end-to-end or side-by-side in an identical manner to form the whole structure. A railway line on equi-spaced sleepers is the oldest example. The proposed truss-structure of the space station is the most recent. The regularly stiffened plates which occur in aerospace and nautical structures are other, oft-quoted examples.

Vibration analyses of these structures are frequently required, and extensive studies of their free harmonic motions have been made over the past 25 years. Brillouin's classic work [1] on wave propagation in periodic structures (in which crystal and electrical structures rather than "structural" structures were considered) has laid the foundation for much of the thinking in these studies. Some of the work on free wave motion in structures which is relevant to the subject matter of this paper is contained in references [2–6].

Forced wave motion has received much less attention, although the motion excited by distributed harmonic pressure fields was reported as long ago as 1971 [7]. Response spectra for an infinite periodic beam on simple supports and subjected to a single-point harmonic force were presented by Mead [8] in 1975. A receptance method of analysis

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