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Letter to the Editor

Structural similitudes for the dynamic response of plates and assemblies of plates

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ABSTRACT

A structural similitude is proposed for the analysis of the dynamic response of plates or assemblies of plates. The similitude is defined by invoking the energy distribution approach which allows the representation of all the fundamental parameters. Then, the similitude laws are defined by looking for equalities in the structural responses. Two test cases are herein discussed: the first involves a single plate response and the second is related to an assembly of two plates. Only the bending waves are taken into account. If the original damping values are kept, a complete similitude is defined in both the cases which allows to enlarge or reduce independently the plate surfaces and the thickness. An approximate similitude is defined if the damping is modified: in this case only a mean response can be predicted in similitude.

1. Introduction

It is well-known that the possibility to transport the same engineering problem in different scales can offer several advantages. Thinking only to the geometry, a very small object could be investigated in a scale larger than the original one, so making easy the location of a given set of sensors. On the contrary, very large structural components can be analysed in a standard laboratory by using a concentrated set of excitation and acquisition instrumentation and with small surfaces to be controlled.

The theory of the models and the analysis of the possible similitudes and analogies is a very large branch of the engineering literature and cannot be replicated here. An interesting summary of the similarity conditions between a full-scale model and a scaled one, by using the modal approach, is given in [1], with specific reference to dynamic response. A more general view of the problem is in [2], even if the main textbooks about this subject are the work in [3,4].

The approach of the similitudes between models is largely used in the aeroelastic tests where, during the wind tunnel measurements, the aircraft component is designed to represent the same natural frequencies or flutter speed and/or the wind-tunnel data have to be correlated to the flight-test ones, [5].

The relationships among mode shapes, natural frequencies, damping loss factors and energies are in [6] where the energy distribution approach (EDA) is introduced. EDA was specifically used in order to predict the original and scaled responses of linear dynamic systems, [7–9]. In detail, some investigations for a simple plate are in [7], and the extension to two plates is in [8]; the scaling between structural components with different modal density (a beam coupled with a plate) is introduced in [9]. The configurations were very simple but the results were very attractive when comparing them to those obtainable with large finite element models.

In the present work, the idea is to enlarge the number of parameters in order to generate a complete similitude and to set-up similitude laws for some coefficients able to represent some of the items to be investigated.

The adopted approach would formally invoke the process of full dimensional analysis, [3], but here it is preferred to work with the energy distribution approach (EDA) that allows the investigation of a dynamic system via the modes and natural frequencies in order to determine the power input and the energy associated to each subsystem.

The work, after these introductive remarks, presents in Section 2 a summary of EDA. This approach is then used to define a similitude with a parent model tailored for representing some specific items under observation. Section 3 contains the numerical investigations concerning the dynamic response of a simple bending plate and an assembly of two bending plates.

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