Acoustic Response of a Multilayer Panel with Viscoelastic Material

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The development of materials both rigid and light with high damping effect and acoustic insulation is possible by using a multilayer panel with viscoelastic material. The rigidity of a multilayer panel is provided by its elastic layers, and damping is provided by viscoelastic layers. Prediction of the behavior of such systems in the conception phase is very important to determine the most important parameters in a multilayer panel in the aim to maximize insulation and to properly design this panel for several applications. In this work we have developed a model based on transfer matrix method, which is an analytic method to predict behavior of infinite layer subjected to a plane wave with an oblique incidence.

Notation

- \( v_1 \): Velocity in the \( x_1 \) direction
- \( v_3 \): Velocity in the \( x_3 \) direction
- \( G \): Shear modulus
- \( \nu \): Poisson’s ratio
- \( \rho \): Mass density
- \( \omega \): Angular frequency
- \( k_{\text{comp}} \): Wave number of compressional wave
- \( k_{\text{cis}} \): Wave number of shear wave
- \( \phi \): Compressional wave potential
- \( \psi \): Shear wave potential
- \( k_{1} \): Wave number in the \( x_1 \) direction
- \( k_{3} \): Wave number of the compressional wave in the \( x_3 \) direction
- \( k_{3} \): Wave number of the shear wave in the \( x_3 \) direction
- \( \sigma_{33} \): Normal stress
- \( \sigma_{31} \): Shear stress
- \( p \): Pression of the fluid
- \( V \): State vector
- \( I_{r,s}, J_{r,s} \): Interface matrix
- \( L_{r,f}, J_{s,f} \): Interface matrix
- \( T \): Transfer matrix
- \( Z_c \): Characteristic impedance of the fluid
- \( Z_a \): Impedance at the left-hand side of the material
- \( Z_{3a} \): Impedance at the left-hand side of the material

1. INTRODUCTION

Multilayer panels are widely used as sound insulation in automotive industries and building acoustics. Studies of acoustic response and wave propagation through stratified material are of paramount importance for the optimum design of a multilayer panel that is both rigid and light. In order to increase acoustic insulation properties of multilayered panels, many configurations including plates, impervious screens, and layers of air and viscoelastic media have been studied. The behavior of these combinations of materials depends more or less on the dimensions and the boundary conditions at the edges. Nevertheless, interesting results can be obtained by modelling the samples as infinite plates subjected to incident plane waves. Using the transfer matrix related to each layer considerably