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Structure-borne sound propagation calculation with Maxwell element

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ABSTRACT

When simulating structural vibrations in light weight construction, many details and circumstances are important and yet not easily modeled a priori. In this project inverse methods are used to provide necessary information. To be able to make a reliable simulation model for the acoustic attenuation prediction calculations, the possibilities of using Maxwell elements to capture the kinetic energy dissipations are investigated and tested numerically [1, 2, and 3].

The average energy dissipation and the development of evanescent wave propagation for a T-junction that contains either a continuous plate, like a chipboard plate, and bearing beams or two separate plates and a bearing beam. These structures have been investigated experimentally with the help of an array of accelerometers at different locations on sub models. The change in bending moment and rotation angles of the flexure wave propagation in the plates due to the torsional wave propagation has been investigated experimentally with the help of back scattering formulation. The determination of phase change can be achived with the elastic causality theorem, where the traveling waves in each direction is assumed to have two travelling paths. Each and every heterogeneity characteristics of the structure are determined with the help of individual measurements.

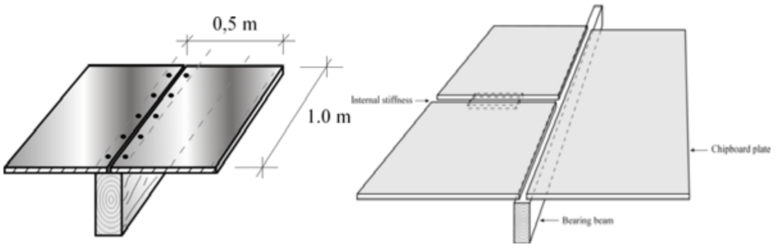


Figure 1: Exploded view of the floor substructure with its components; the chipboard plate, bearing beam internal stiffeners at free edges of the chipboard plate and interface element between the components to model local behaviour.

The difference in the time domain is caused by the geometrical discontinuity which can be captured of a Green function formulation. The phase difference of the propagation phase relations at both sides of the discontinuity can be determined for each frequency.

The floor structure in the simulation is modelled with solid elements. The orthotropic material models of the bearing beam and chipboard in the simulations are inspired from the material models that have been used in the fracture mechanics calculations. The chipboards are modelled with eight-node solid elements and the bearing spruce beams are modelled with nine-node solid elements. The discontinuities at the joints where two chipboards are fastened together are modelled with an interface element between the structural components.

The results from the wave propagation measurements can be used later as input parameters in the Maxwell element formulation in the finite element simulation model.

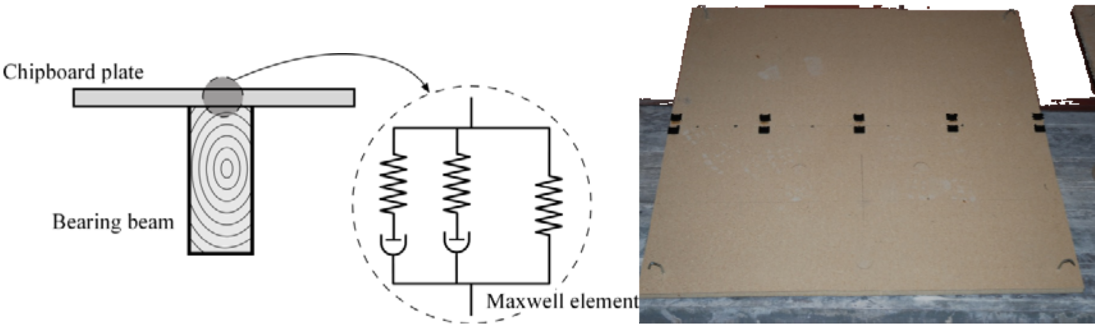
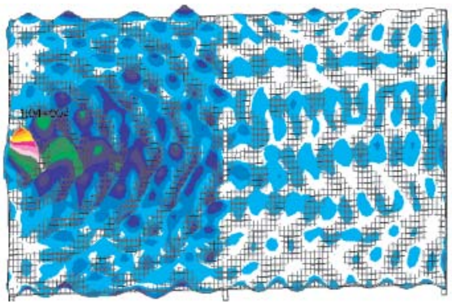


Figure3: Schematic figure of how the interface between the chipboard and the beam are modelled by means of Maxwell elements. By inverse modelling the parameters for the Maxwell element is determined.

The corresponding damping matrix in the model is formulated using the energy dissipation estimation from the measurement results. The visco-elastic coupling in the simulation gives a smeared model than a descrete coupling, since the calibration of the change of bending moment and rotational angles from the measurements are also average values. To be able to catch the change of displacements in the wave propagation process, a complex damping model is used in the calculation of the change of the directional structure acoustic intensity.

Structure-borne sound radiation is created by the transverse deflection of the floor structure, the source of the structure borne sound is assumed to be an impact excitation. Regardless if the excitation occurs on the joist or on the bay side, the magnitude of the transverse deflection and the stress wave propagation from the finite element simulations can give a reliable prediction model of the sound level from the floor element. The modal analysis of the acoustic wave propagation in the fluid domain can be coupled to the vibration pattern, calculated from the finite element simulations.



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