MATELYS
RESEARCH LAB

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

ENTPE

UNIVERSITÉ DE LYON

NO2NOISE

Summary of research work

PhD duration: 2019-2021

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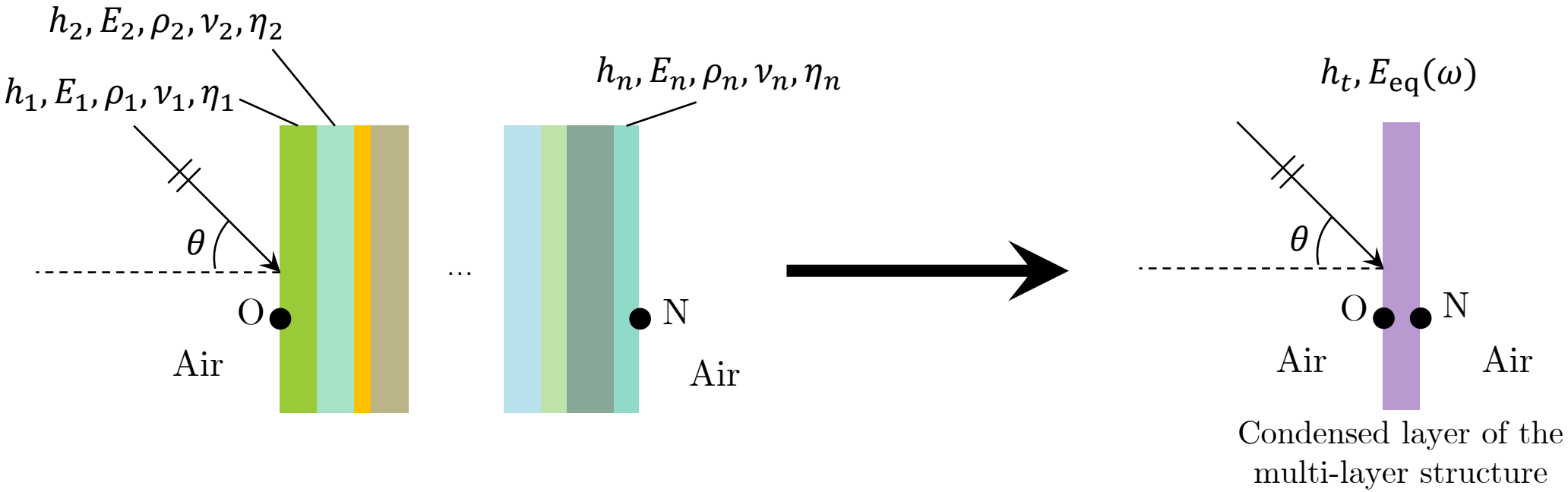
Supervisors:
Dr. Dimitrios Chronopoulos
Dr. Emmanuel Gourdon
Eng. Fabien Chevillotte
Prof. Gregor Tanner

Condensed models



Layer-wise models

- Each layer must be meshed according to its nature
- Results in larger number of degrees of freedom
- Requires huge computational time

Condensed models

- Converts the multi-layer into a single equivalent layer
- Reduces computational time
- Helps to understand the physical behaviours of the multi-layers

Objectives of the PhD

1

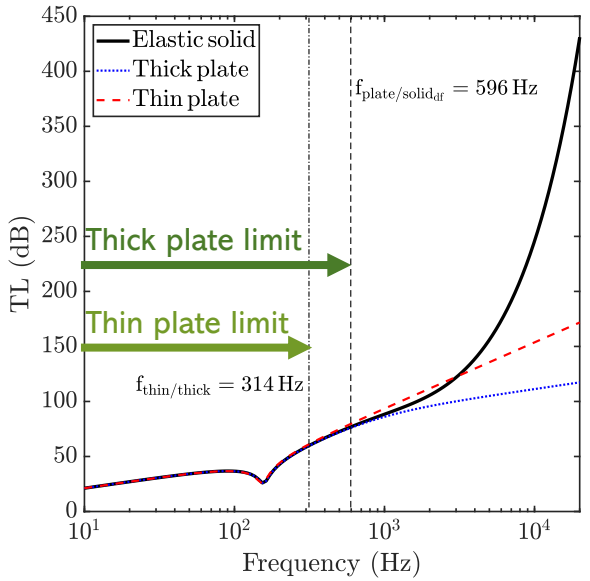
Develop analytical expressions for the frequency limits of plate theories

Context: Although thin and thick plate theories are commonly used by many vibro-acoustic models (including condensed models), the applicable frequency limits are not well defined in the literature.

Methodology: Using the analyses of wavenumbers and admittances obtained from thin and thick plate theories, the analytical expressions for the frequency limits are derived.

Status: Completed and published. (Link)

Arasan, U., Marchetti, F., Chevillotte, F., Tanner, G., Chronopoulos, D., Gourdon, E. "On the accuracy limits of plate theories for vibro-acoustic predictions". *Journal of Sound and Vibration* (2021)



Objectives of the PhD

2 Develop a simple condensed/equivalent plate model for three-layer plates

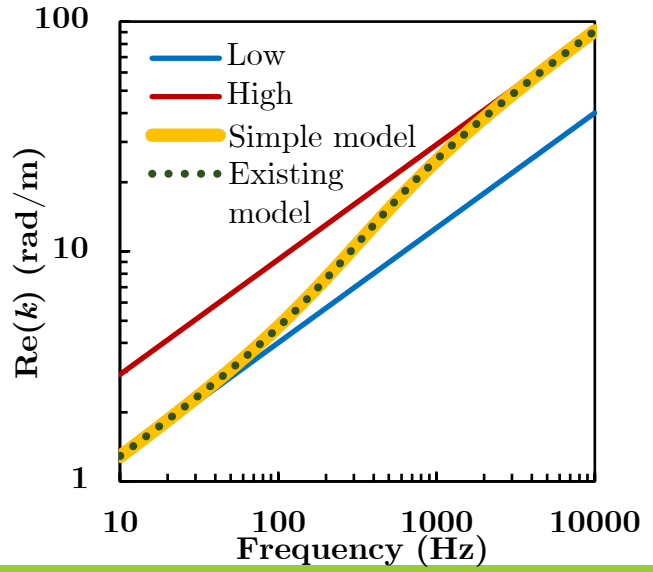
Context: Although few condensed/equivalent plate models are available in the literature, they often result in challenging implementation processes due to the complex formulations involved.

Methodology: By identifying the physical asymptotic behaviours of a three-layer system at low, high and transition frequencies, a simple model is developed to construct the system's behaviour at all frequencies.

Status: Completed and published. (Link)

Arasan, U., Marchetti, F., Chevillotte, F., Jaouen, L., Chronopoulos, D., Gourdon, E. "A simple equivalent plate model for dynamic bending stiffness of three-layer sandwich panels with shearing core". *Journal of Sound and Vibration* (2021)

Simple equivalent plate model	Advantages	Limitations
	• Easier to implement • Useful for optimization • Helpful to understand physical behaviours	• Three-layer systems only • Layers must be isotropic • Dilatational effects are not included



Objectives of the PhD

3 Develop a condensed model to include dilatational behaviour of multi-layer structures

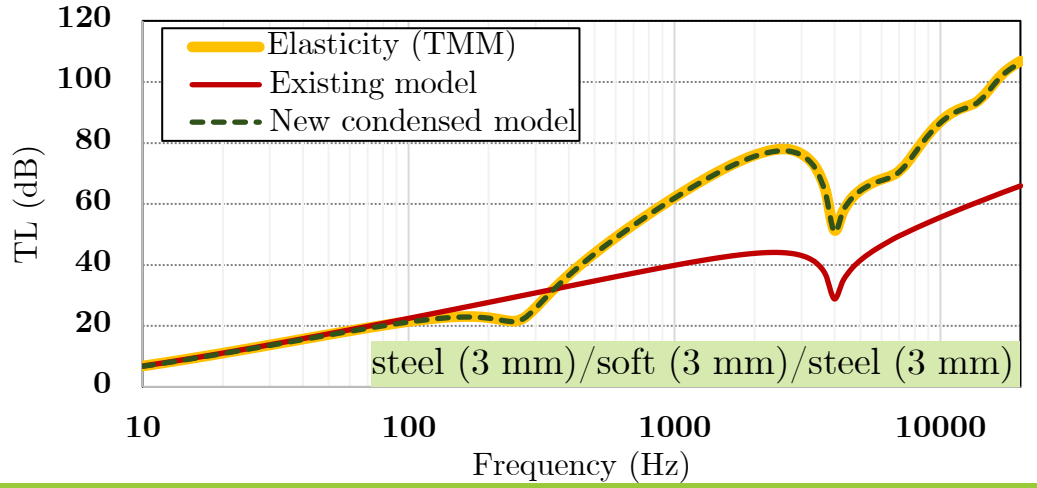
Context: Existing condensed/equivalent plate models include only anti-symmetric motions like bending, shear and do not include symmetric motions (compressional/dilatational/breathing effects).

Methodology: By analysing the anti-symmetric and symmetric admittances of multi-layer structures, two dynamic mass properties are defined from the admittances at normal incidence. Along with these two properties, dynamic bending stiffness (from existing condensed plate models) also would be used to condense the vibro-acoustic behaviour of the multi-layer system.

Status: Completed and published. (Link)

Marchetti, F., Arasan, U., Chevillotte, F., Ege, K. "On the condensation of thick symmetric multilayer panels including dilatational motion". *Journal of Sound and Vibration* (2021)

	Advantages	Limitations
New condensed model	• Applicable to thick structures • Layers can be fluid, solid and poroelastic	• Only for physically symmetric multi-layer structures • Not for layers with low resistivity (< 1000 N s m^{-4})



Objectives of the PhD

4 Develop a finite element scheme to implement the developed condensed model

Context: A finite element framework needs to be developed to implement a condensed model, which includes the dilatational motion, to reduce the computational time compared to the conventional 3D finite element approach.

Methodology: By meshing two decoupled plates corresponding to symmetric and anti-symmetric motions (with dynamic mass and bending stiffness properties) and coupling them through fluid velocities at emission and reception sides, vibro-acoustic quantities (transmission loss, for example) can be obtained.

Status: Completed and research article is in progress.

FE scheme for the new condensed model	Advantages	Limitations
	• 15 times faster than 3D FE approach • Applicable to thick structures • Layers can be fluid, solid and poroelastic	• Only for physically symmetric multi-layer structures • Not for layers with low resistivity (< 1000 N s m^{-4}) • Rotational inertia is ignored