An Indirect Trefftz Method for layered plate assemblies

Name: Hannes Englert  
E-Mail: hannes.englert@tum.de  
Supervisor: Prof. Dr.-Ing. habil. Gerhard Müller  
Chair of Structural Mechanics  
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Problem description
Vibro-acoustic behaviour of physical systems is an important task in engineering acoustics. Acoustic problems cover the whole frequency range between 20 Hz going up to 20 kHz. In the low frequency range exists wide knowledge on how to approach numerical tasks, e.g. with the help of element based methods such as Finite-Element-Methods (FEM) and Boundary-Element-Methods (BEM). Statistical methods, namely the Statistical Energy Analysis (SEA), can handle high frequencies if certain preconditions are fulfilled. In contradiction there is still a lack of knowledge about the frequency range in between, the so called mid-frequency gap. In this range the numerical effort for element based methods increases rapidly, while on the other hand the conditions for statistical methods aren’t fulfilled sufficiently. Furthermore element based methods in the range of higher frequencies suffer from pollution errors mainly caused by the discrepancy between the numerical and analytical wavelengths. A lot of effort has been put into resolving this deficiencies for either method. Some examples are element enrichments techniques as well as extensions to the SEA.

Indirect Trefftz methods
In comparison to element based methods, Trefftz methods are using a set of basis functions that inherently satisfy the Helmholtz equation underlying the problem of consideration. One method based on the indirect Trefftz approach is the Wave Based Method developed by W. Desmet [1], which meanwhile has been successfully tested on various acoustics problems. The method approximates the solution by so called wave functions (Fig. 1). With the help of a weighted residual approach, the integrated errors over the domain boundaries are minimized. The unknowns are the Contribution factors of the different wave functions. According to [3] the method has its shortcomings in being limited to geometries of rather low complexity. [3]
The wave based method has been successfully implemented for plate assemblies as well as steady state acoustic problems. Since then various extensions have been added to the method itself. [2]

![Exemplary wave functions for 2D problems](image)

**Fig. 1: Exemplary wave functions for 2D problems**

**Multi Layered Plate**

The method shall be extended to multi-layered plate assemblies. Therefore the purpose is to investigate the acoustics behaviour of such structures. A possible application field would be cross laminated timber as used in building ceilings. Besides modelling and adopting the orthotropic material behaviour of such systems, a description for the boundary conditions between the different layers needs to be found.

**References**

