Mitigation of Structure Borne Noise in the Wooden Panels by Periodic Stiffening

Domadiya, Parthkumar Gandalal

Publication date:
2011

Document Version
Early version, also known as pre-print

AALBORG UNIVERSITY

EUROPEISKA UNIONEN
Europeiska regionala utvecklingsfonden

Interreg IV A
ÖRESUND – KATTEGAT – SKAGERRAK

Mitigation of Structure Borne Noise in Wooden Panels by Periodic Stiffening

Department of Civil Engineering, Aalborg University, Denmark

BACKGROUND

Lightweight building structures are highly encouraged for new building designs. Since noise transmission within lightweight structure has became an potential problem. Current trend towards light-weight constructions may be of both economic and environmental benefit by saving of material and transportation energy, the trend also requires development of new design tools against generation of noise because there is a very complicated, design-dependent trade-off between reduction of structural weight and reduction of the level of sound and vibration.

Walls and floors in lightweight timber structures are usually constructed as wooden panels. The sound may passes around, over the top or under the primary partition separating two spaces. For heavy structures, e.g. concrete buildings, statistical energy analysis (SEA) has been found to provide a reliable framework for prediction on noise transmission. However, SEA has limited validity for lightweight structures such as wooden floors with joists spanning in one direction or double-plate panel walls with vertical ribs.

The periodic nature of the stiffening provides a nonhomogeneous modal density due to the formation of stop bands. Thus, the vibrations are not diffuse and the number of modes in certain frequency bands may be limited. Hence, other methods of analysis must be used. Finite element approach towards noise transmission in low frequency range within lightweight panel structure has been tested.

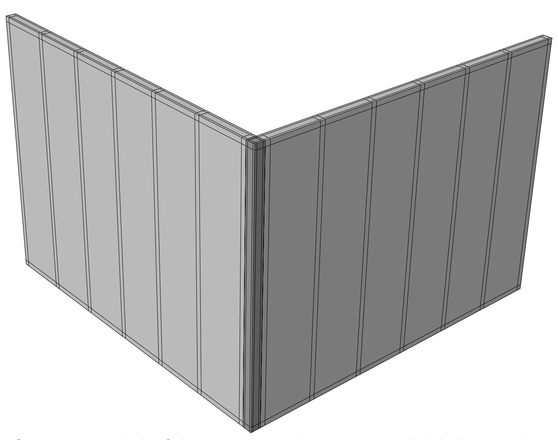
"STATE OF THE ART"

Nature of the periodic structures towards sound radiation was analysed in different conditions in past. (Takahashi 1983, Mace 1980)

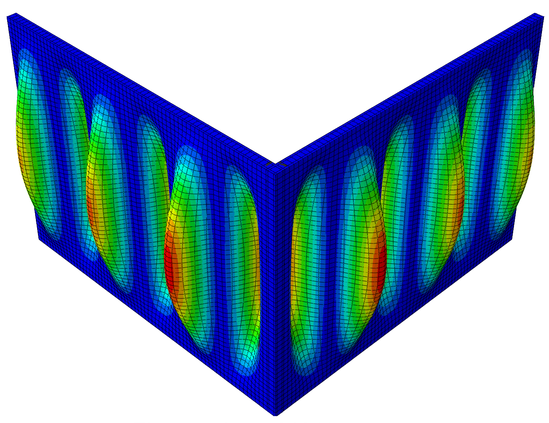
Theoretical and experimental evaluation of the application of EN12345-1 was also described for flanking noise transmission in lightweight building structures using SEA method. (Mahn 2007)

Transmission of vibrational energy via flanking junctions to the point of radiation within finite periodic rib stiffened plate has been analysed, extraction of results became too complicated when the high number of junctions comes into account. (Nightingale 2005)

Finite element method (FEM) can be used to describe the flanking transmission in dwellings; numerical simulations can reduce the cost of experiments and could improve the sound insulation . FEM method has also certain limitations when it comes to high frequency range, so it requires some hybrid methods to reduce the cost of simulation like Hybrid FE-SEA, wave approach. Commercial finite element package ABAQUS will be used to prepare finite element model and analysis of periodic structures.



Current model of the two panel structure which is used in priliminary phase of research



Eigenmode at 342 Hz

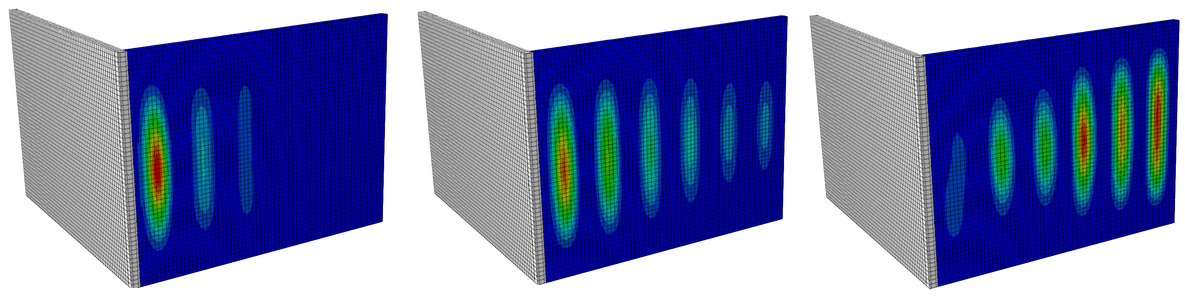
OBJECTIVE OF THE STUDY

The objective of this research project is to minimize the transmission and emission by embedment of periodic stiffeners within the panels. Periodic structures have been studied in relation to pipes and similar one dimensional structures. Here it has been found that periodicity introduced in right manner, may diminish wave propagation significantly within prescribed frequency ranges. The similar results are expected for wooden panels, where vibration caused by line sources as well as point sources.

The basic aim is to develop analytical solutions that can be utilized for design and employing different theories like Floquet theory to functions with radial periodicity and comparison with finite element results.

PRELIMINARY PHASE OF RESEARCH

In preliminary phase of research, a finite element model is utilized for the analysis of noise transmission in a lightweight two panel structure consisting of two plates with internal ribs. It is focused on flanking noise within a panel structure of finite size. Modelling of lightweight structure is complicated since it contains various materials, junctions, coupling methods and acoustic medium which has to be coupled in a specific way. Present research is concerned with flanking energy transmission in two adjacent walls with and without acoustic medium, also an effect of



Energy distribution over receiving wall at 394.1 Hz, 402.2 Hz and 410.4 Hz (From left) when the concentrated point force was presented over another wall.

Finite element model is structured in the commercial FEM pacakage ABAQUS using solid continuum finite elements for the structure and fluid continuum elements for the air inclusions in the finite cavities. The fluid structure coupling is generated by using tie constraints within ABAQUS.

Energy transfer level at receving wall is extracted under three different specifications. 1) with and without acoustic cavity 2) with and without damping inclusions 3) point concentrated force on another wall at three different positions. Strong coupling between structural modes and acoustic modes is seen under three different load positions at receiving wall within different range of frequencies.

ACKNOWLEDGEMENT

The present research is part of the InterReg Project "Silent Spaces", funded by European Union. The author highly appreciate the financial support.

REFERENCES

R.H. Lyon, R.G. DeJong, *Theory and application of statistical energy analysis*. 2nd edition. Butterworth-Heinemann, 1996.

L. Galbrun, *Vibration transmission through plate/beam structures typical of leightweight buildings: applicability and limitations of fundamental theories.* Applied Acoustics 71, 587-596, 2010.

D. Takahashi, *Sound radiation from periodically connected double-plate structures*. Journal of Sound and Vibration, 90(4), 541-557, 1983.

B.R. Mace, *Sound radiation from a plate reinforced by two sets of parallel stiffeners*. Journal of Sound and Vibration , 71(3), 435-441, 1980.

T.R.T. Nightingale, *on the distribution of transverse vibration in a periodic rib stiffened plate*. Forum Acusticum 2005.

J. Mahn, *Prediction of flanking noise transmission in lightweight building constructions: A theoretical and experimental evaluation of the application of EN12354-1.* Technical report, University of Canterbury, Acoustics Research Group,2007.

"ABAQUS Analysis, User's Manual-version 6.10". Dassault Systems-Simulia corp. Providence, RI, USA

Parth Domadiya
pdg@civil.aau.dk
First Year PhD student