Mathematical Model for Prediction of Transmission Loss for Clay Brick Walls

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Introduction:
In this work an evaluation of sound transmisson class of building structures is made by numerical model (fig.1) and compared with laboratory measurements.

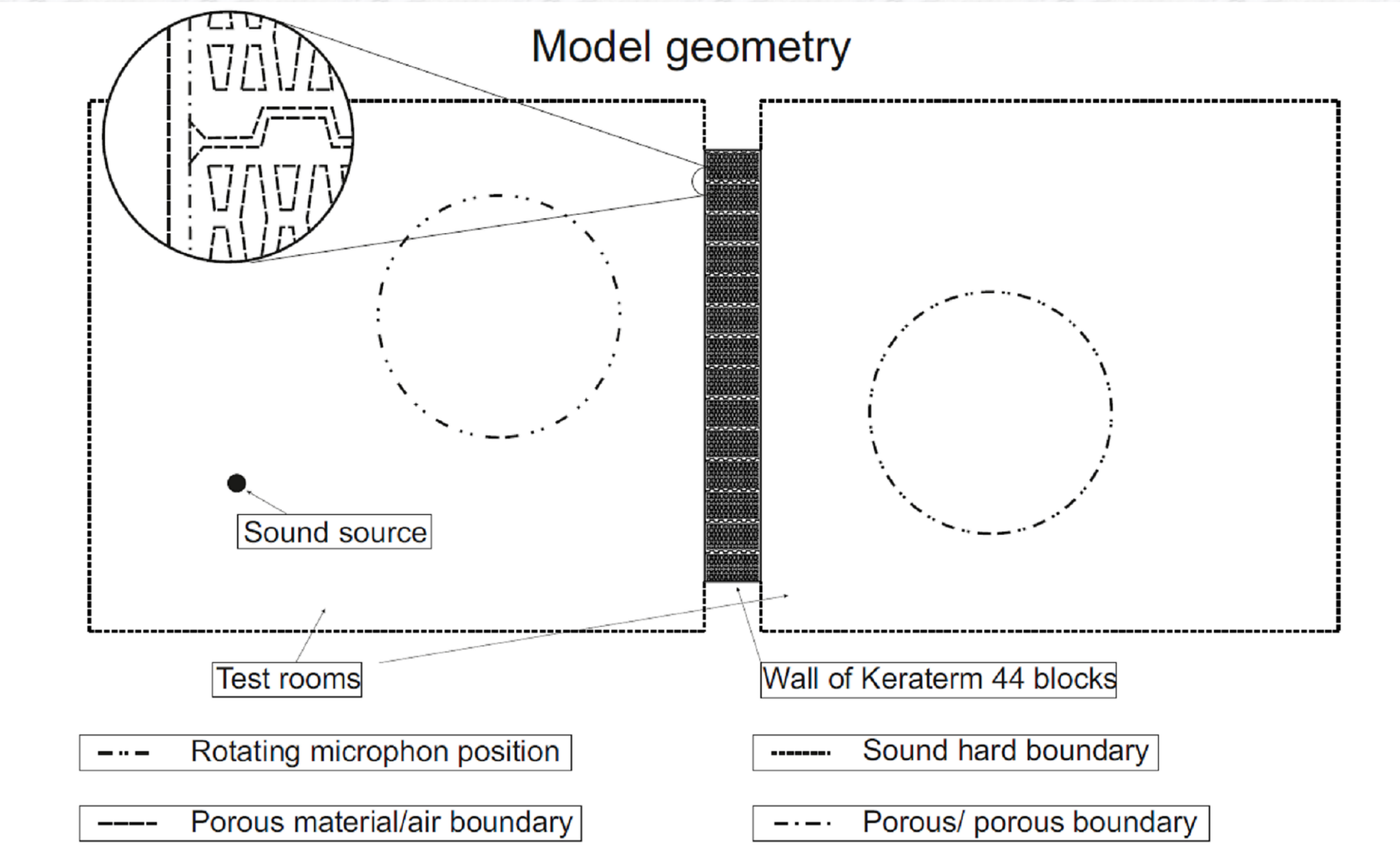

Figure 1. Geometry of numerical model and boundary conditions.

Governing equations:
For numerical sumulation a Comsol Multiphysics Elastic waves module was used. For air domain Helmholtz equation is used:

$$\nabla\left(-\frac{1}{\rho}(\nabla \mathrm{p})\right)-\frac{\omega^2 p}{\rho c^2}=2\sqrt{\frac{P\omega}{\rho}}$$

For solid domains structural mechanic:

$$-\rho\omega^2 u - i\eta\omega u + \nabla(\nabla \mathrm{u}) = 0$$

For porous domain the *Biot* equations:

$$\begin{cases} -\omega^2\left(\rho_{av}-\frac{\rho_f^2}{\rho_c}\right)u-\nabla(\sigma_{dr}0)=0 \\ -\frac{\omega^2}{M}p_f+\nabla\left(-\frac{1}{\rho_c}(\nabla p_f 0)\right)=0 \end{cases}$$

Boundary conditions:
Impedance at the test room boundaries:

$$-n\left(-\frac{1}{\rho}(\nabla p)\right)=-\frac{i\omega p}{Z}$$

Fixed for the test wall boundaries:

$$u=0$$

Results:
The diffuse sound field was aquired for middle and high frequency range.
Numerical simulation give the same sound reduction index values as the experiment.
Biot equations underestimate the sound reduction properties of clay brick. An additional damping term must be introduced in order to use those equations.

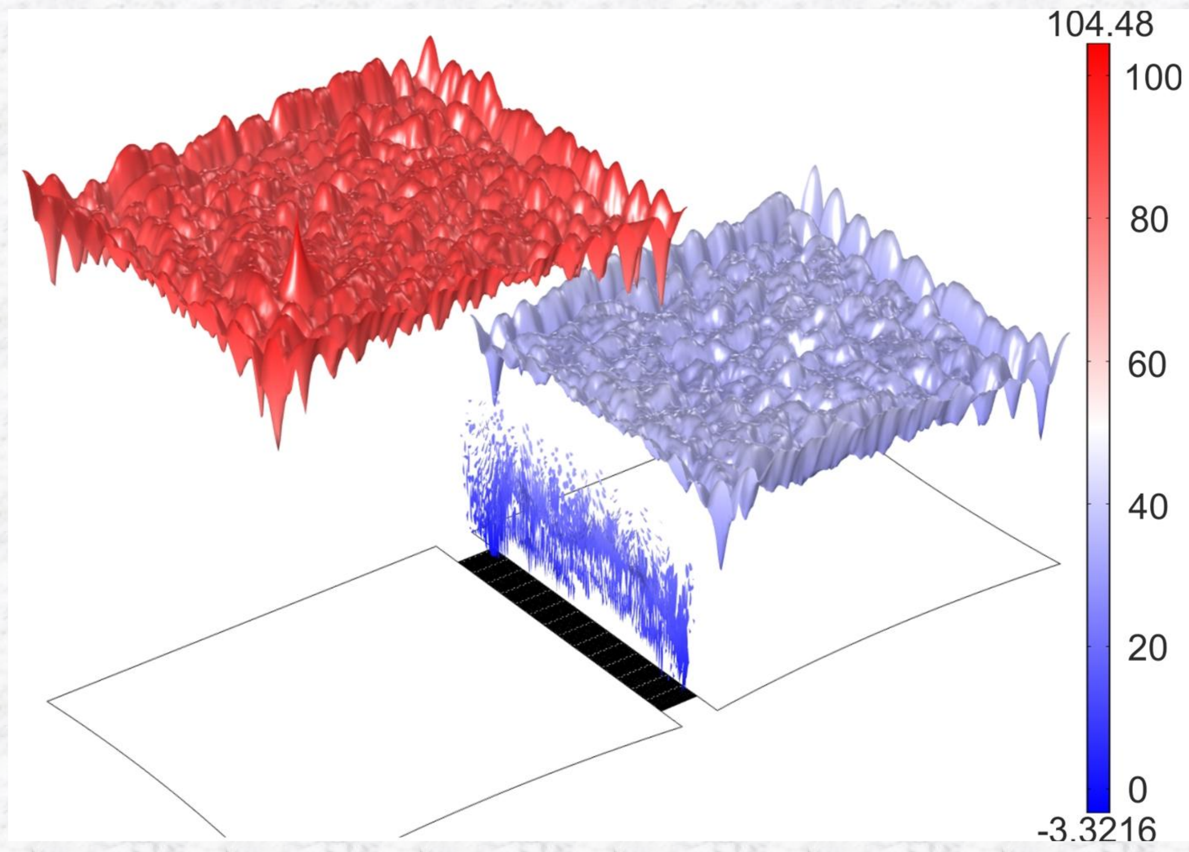

Figure 2. Superposition of monofrequencies for one–third octave band 500 Hz middle frequency.

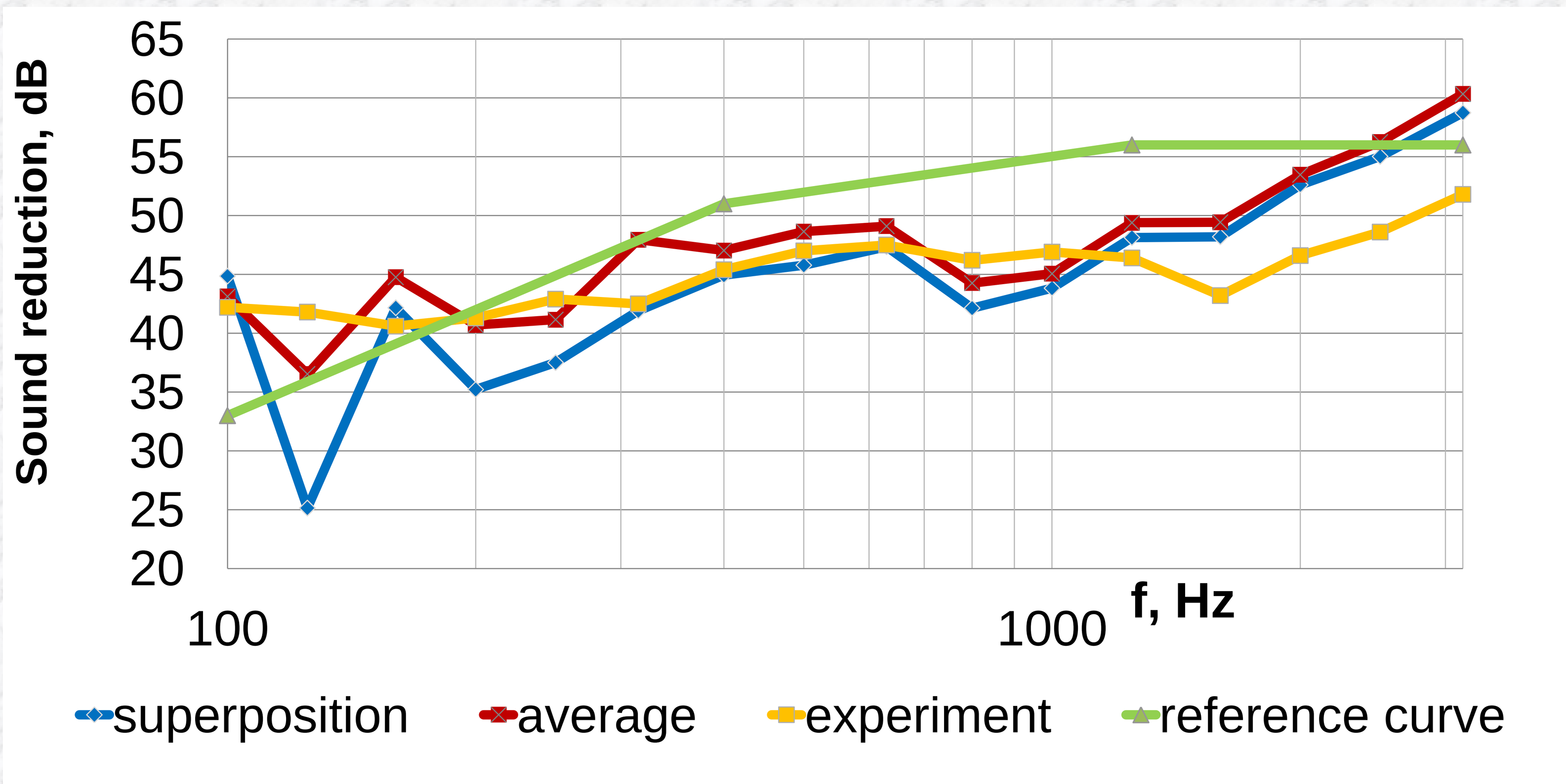

Figure 3. Sound reduction over one-third octave bands, compared to experiment.

Conclusions:
The developed model can be used to predict sound reduction index for building structures in middle and high frequency range.
Numerical model can not replace experiment jet.

References:

1. Papadopoulos, C. I., Development of an optimized standard-compliant procedure to calculate sound transmission loss: Design of transmission rooms *Applied Acoustics 63*, 1003-1029, (2002))
2. Allard, J.F., Atalla, N. Propagation of sound in porous media: modelling sound absorbing materials, second edition, *John Wiley and Sons Ltd*., ISBN 978-0-470-74661-5, (2009)

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