Case study

Development of an interference-based noise barrier via simulations

Based on an interview with Mathias Barbagallo, PhD, Senior CAE Engineer at FS Dynamics

Mathias Barbagallo, a senior CAE Engineer at FS Dynamics, contributed to the development of an interference-based noise barrier by validating acoustic simulations against measurements and then performing new virtual measurements using Actran.

Highways and train tracks often pass within urban regions contributing to increased noise levels which may be annoying and harmful for the residents of these regions. To reduce noise levels and meet regulations, the usage of noise barriers is often required.

These barriers, a kind of passive noise control measures, fulfil their scope by taking advantage of sound phenomena such as reflection, absorption, diffraction and interference. Wavebreaker is a Swedish company that develops innovative noise barriers based on the interference phenomenon, and FS Dynamics assisted them during the developing phase of this noise barrier.

Figure 1. Acoustic barriers (left) and additions to them (right).

Wavebreaker's solution consists of an additional element, a kind of box with open channels creating wave interference, mounted on top of existing barriers, for instance, the one shown to the left. Thus, the noise-insulating performance of current barriers may be improved.

Challenges

The main effort of Mathias Barbagallo, a senior CAE engineer at FS Dynamics and responsible for this project, was to develop a simulation of long-distance sound propagation up to 5 kHz, from a noise source over the barrier and to several receivers up to 20 m high and 100 m from the barrier. The final goal was to perform virtual measurements to calculate the insertion loss for different barrier heights at various distances, to test products and explorative designs. Should this simulation be successful, then it could alleviate the need for field measurements. Since the calculation was to be performed up to 100 m, creating a 3D model would not be feasible due to high-frequency requirements. Instead, Mathias opted for a 2D model because "we couldn't go up to 5000 Hz one-third octave band with a 3D model due to time and resource limitations. Even though we are making simplifications both on the geometry and on the losses in the model, we thought to go around these limitations by not looking at absolute values of sound pressure levels but instead to relative values, like the insertion loss", he notes.

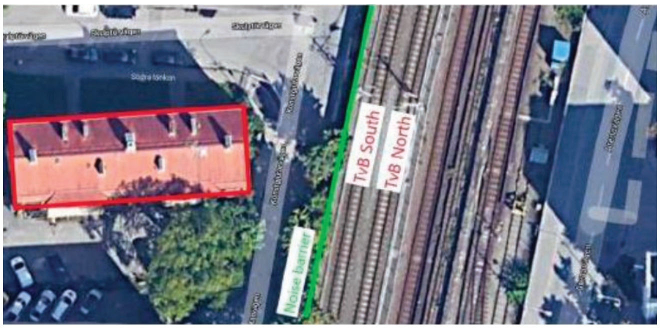

Figure 2. Aerial photo of the urban setting where measurements took place.

Nevertheless, due to the uncertainties and novelty of the calculation setup, it may be risky to blindly trust its results when developing a new commercial product. Hence, another challenge was presented by the validation of the computational model and technique against actual measurements. Two measurement sets were made available to FS Dynamics: laboratory measurements in an anechoic chamber and field measurements in urban environment at short distance, see picture above. Neither set was performed with simulation validation in mind, making comparison harder due to lack of input data and details. These measurement comparisons turned out to be successful, with differences between calculated and measured insertion losses of up to 3 dB, on total levels.

Validation is essential before trusting simulation models, especially since the project's goal was to perform long virtual measurements and design explorative work.

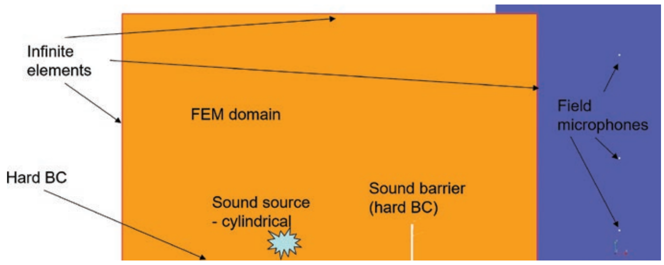

Figure 3. Sketch of the model set-up.

Simulating the barrier

Thanks to their MSC**One** subscription and as Actran was used in previous studies for the same client, Actran was chosen to perform the analysis. The 2D model consisted of a cylindrical source, the sound barrier, infinite elements as a free-field condition; field points were used for simulating microphones at long-distance. Three meshes were created to optimise the calculation time across the frequency spectrum, and a flat or train spectrum was used as amplitude to the excitation.

Similar models were first used for validation against the two sets of measurements mentioned above. Finally, the simulation of interest in open-field up to 100 m was run for several combinations of source-barrier distance and barrier height. Other qualitative metrics were used to verify that the models performed well, like looking at the crossover region between the finite and infinite elements to check that results have a smooth transition between finite and infinite elements domains.

This allows to visually inspect both the quality of this transition and wave phenomena occurring in the vicinity of the noise barrier. The transition occurs where the height of the plot changes, with the FEM mesh to the left and the field map to the right.

> **"The value is that we have provided the client with a way to evaluate their product in specific scenarios, and this is done on a computer without spending money for measurements and without dealing with all the difficult related circumstances, like weather conditions and background noise. So, it's saving money, but also saving a lot of hassle."**

Mathias Barbagallo,
PhD, Senior CAE Engineer at FS Dynamics

Figure 4. Zoom-in at the transition region between finite and infinite elements for reference and Wavebreaker geometries.

Finally, Mathias could use Actran's Python API to perform custom plots of insertion loss for the virtual measurements using data from a field mesh, where he compared results for different screen sizes and source heights to evaluate the screen's effectiveness. Furthermore, Actran's Python API was used to automate post-processing of results.

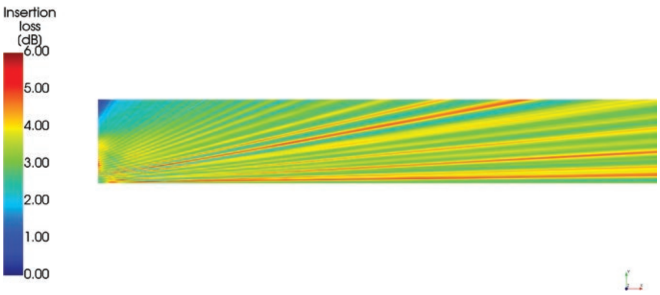

Figure 5. Plot of insertion loss up to 100 m, visualised for the field map computed from the infinite element mesh.

Outcomes

At the end of the study, there was trust in the model for virtual prototyping and virtual measurements. Mathias notes that Wavebreaker "were really happy to see this performance with the measurements. These plots are exactly what they wanted — field maps with the insertion losses."

He further comments that "the value is that we have provided the client with a way to evaluate their product in specific scenarios, and this is done on a computer without spending money for measurements and without dealing with all the difficult related circumstances, like weather conditions and background noise. So, it's saving money, but also saving a lot of hassle."

FS Dynamics also performed some design variation simulations for Wavebreaker. It was quick to explore at an early stage the effectiveness of new ideas to keep working only on the promising ones: "You open your finite element model, test a new geometry, look at the results and then you can understand what's happening with this new data. And this is trustable thanks to the work done to validate the model."

As to what this means for the future of this project, Mathias ends by saying, "We have a good platform to continue helping the client in their future development for new products or new specific projects."

About FS Dynamics

FS Dynamics is a consulting firm entirely concentrated on technical calculations within fluid dynamics (CFD), structural dynamics (FEM) and acoustics. This clear focus, together with the company's high competence and long-term customer relationships are success factors. Today, over 130 CAE engineers are working in our offices in Gothenburg, Stockholm, Lund, Espoo, Hamburg and Lisbon. FS Dynamics has a strong focus both on its in-house business with its own HPC server rooms as well as on-site assignments at customer sites.

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