The Impact of High-Frequency Vibration on the Performance of Railway Fastening Systems

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short-pitch corrugation (Source: Correa, 2011)

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Outline

I: The Impact of High-Frequency Vibration on Fastening Systems

- Dynamic behavior of fastening clamps (eigenmodes)
- Compare eigenfrequencies with excitation frequencies

II: Countermeasures to Avoid Deterioration of Clamps

- Dynamic absorbers
- Modifications to the geometry of clamps
- Modifications to the angle guiding plate

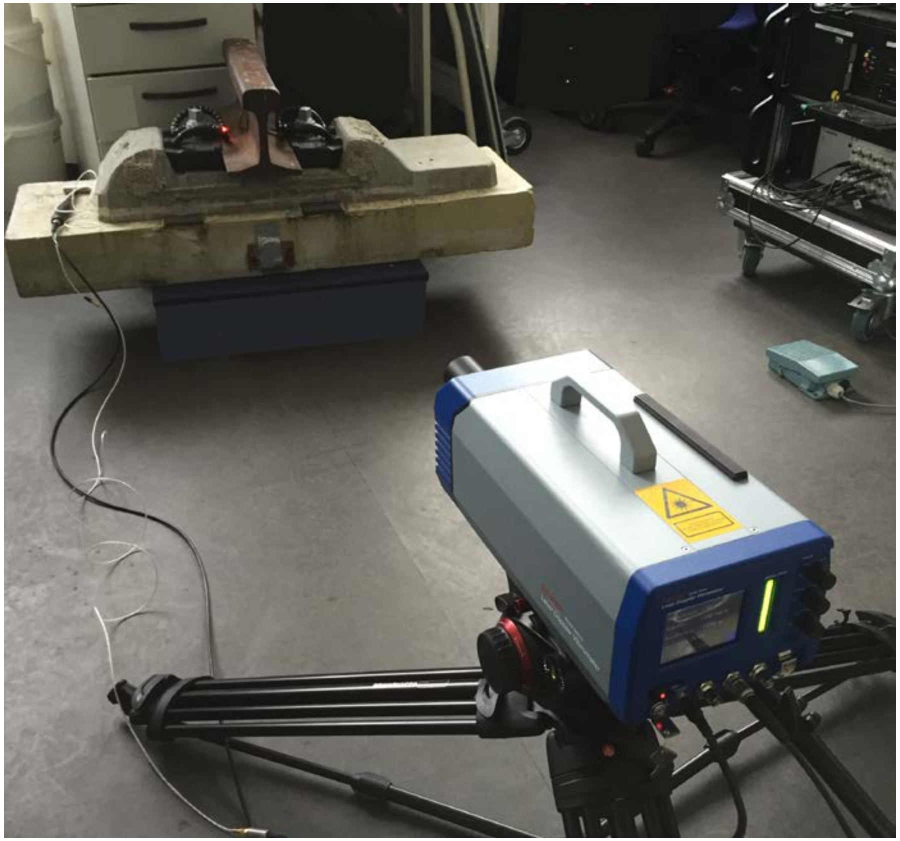
Dynamic Behavior of Skl 15 – Lab Testing

Laboratory Tests to Determine the Eigenmodes

To determine the eigenfrequencies and the corresponding deformation

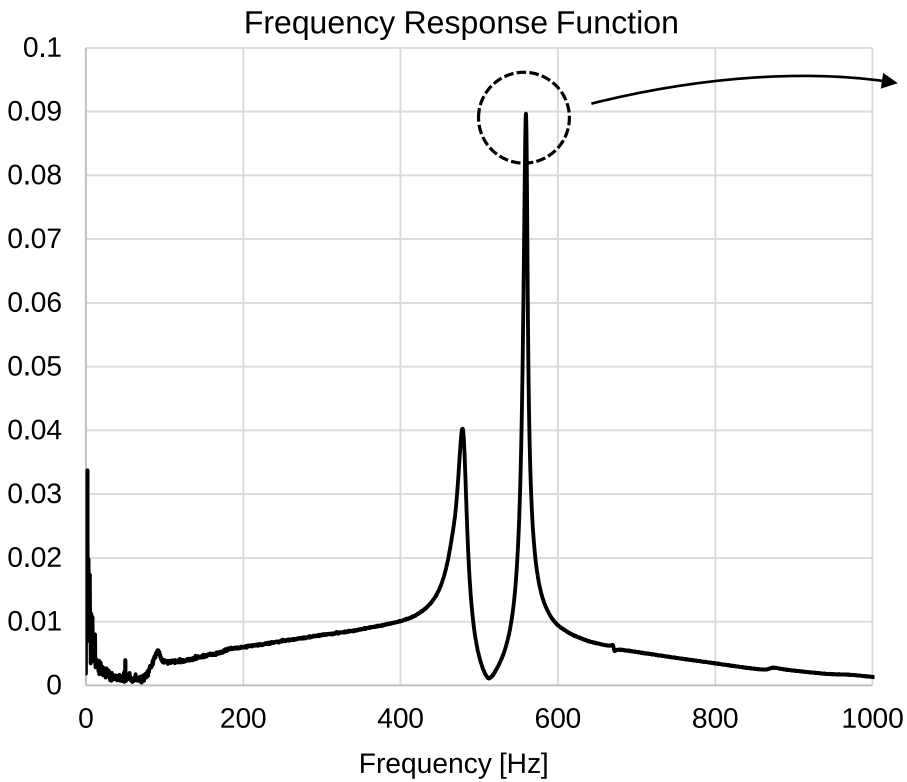
Specimen:
- Single support point
- System 300 mounted

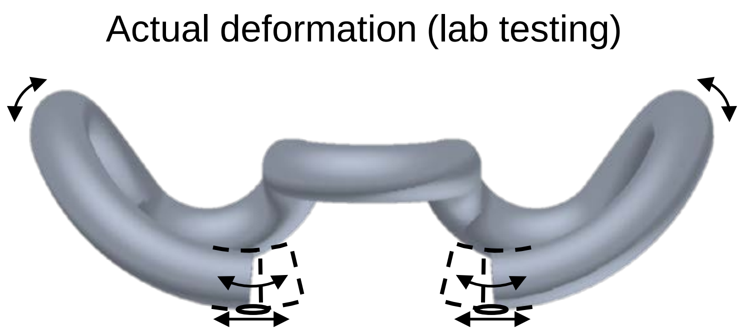
Test equipment:
- Laser Doppler Vibrometer
- Excitation via impact hammer



Dynamic Behavior of Skl 15 – Lab Testing

Laboratory Tests - Results

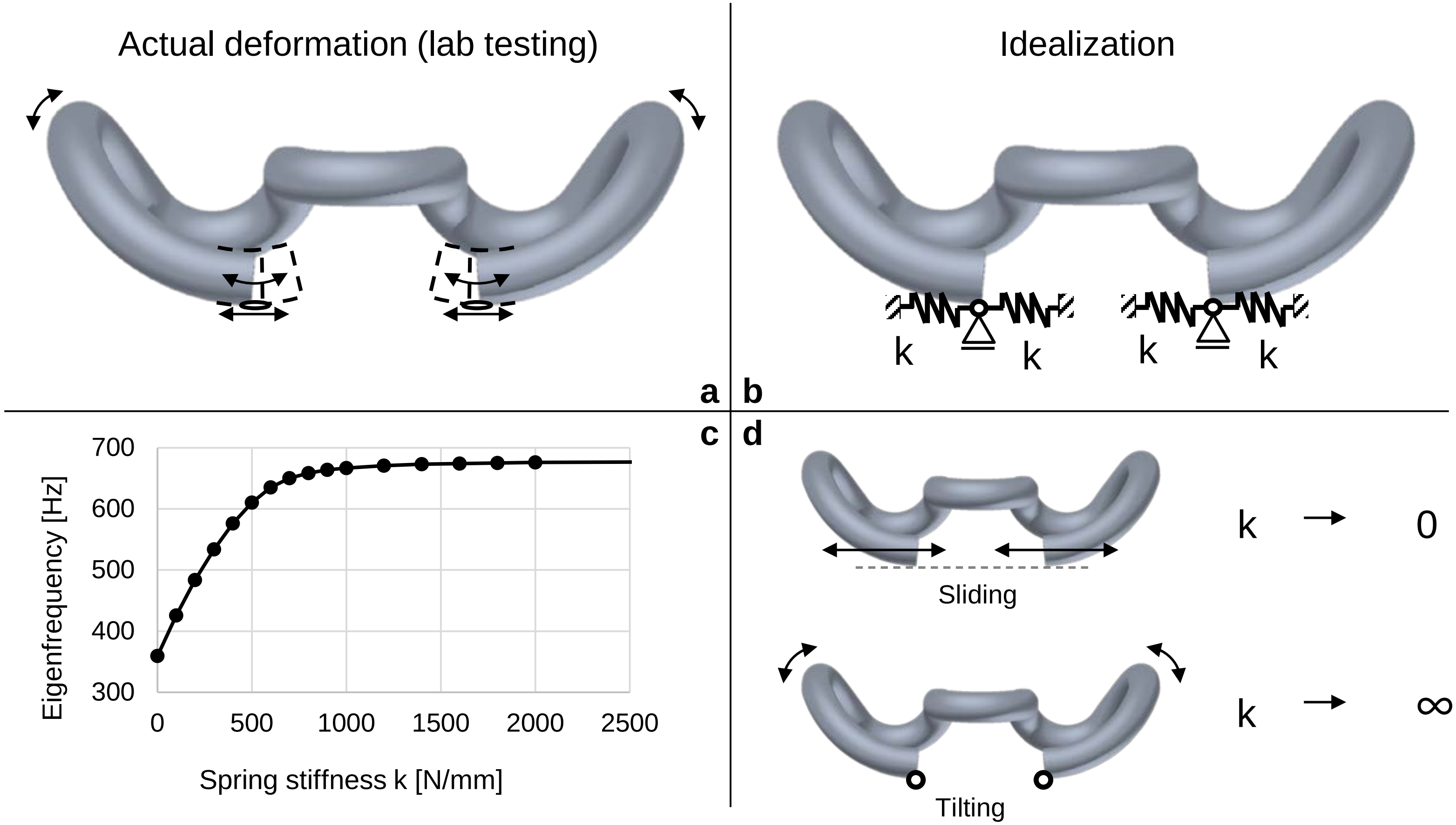




Eigenmode at 570 Hz consists of a combination of a **sliding movement** and a **tilting movement**

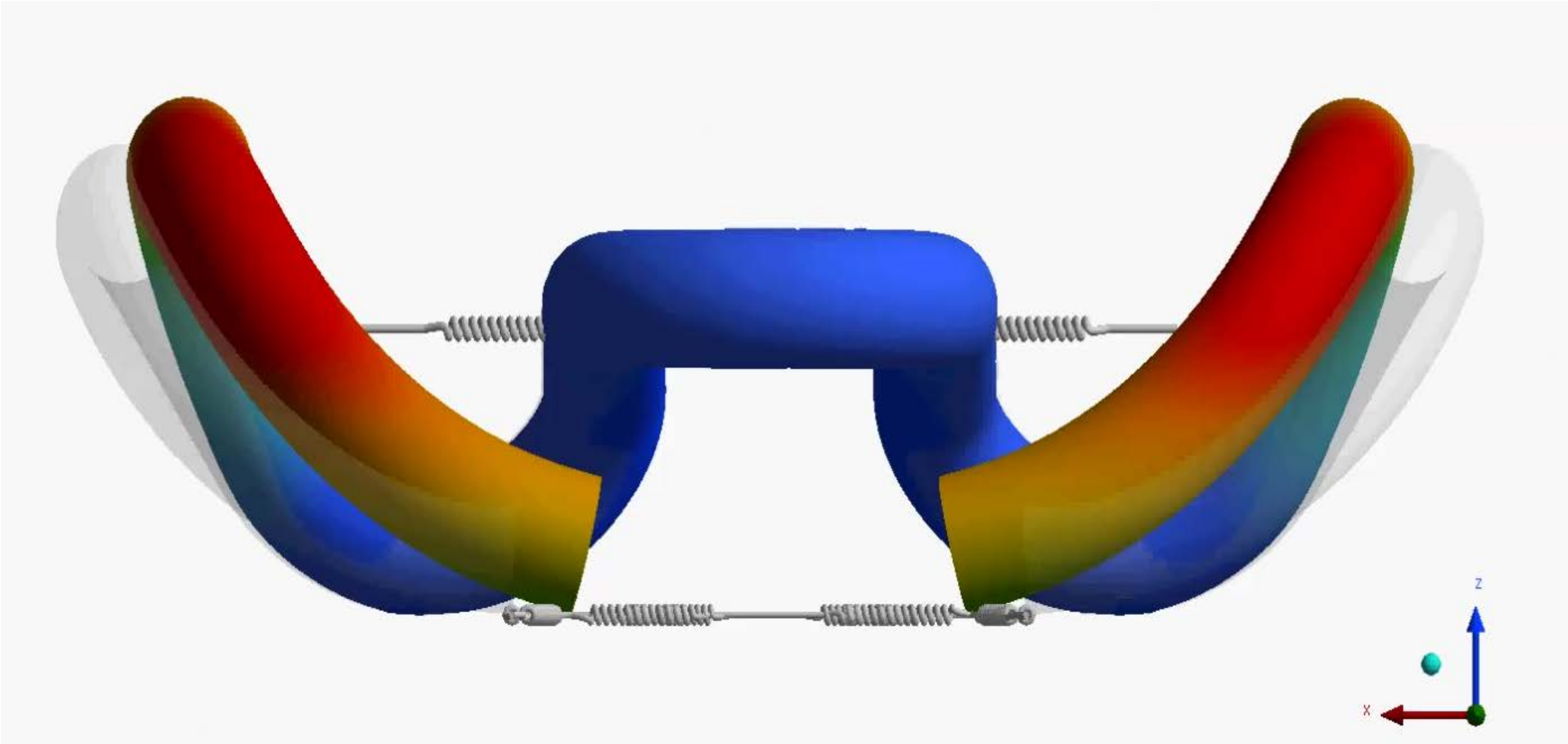
Dynamic Behavior of Skl 15 - FEA

Finite Element Analysis – Model setup

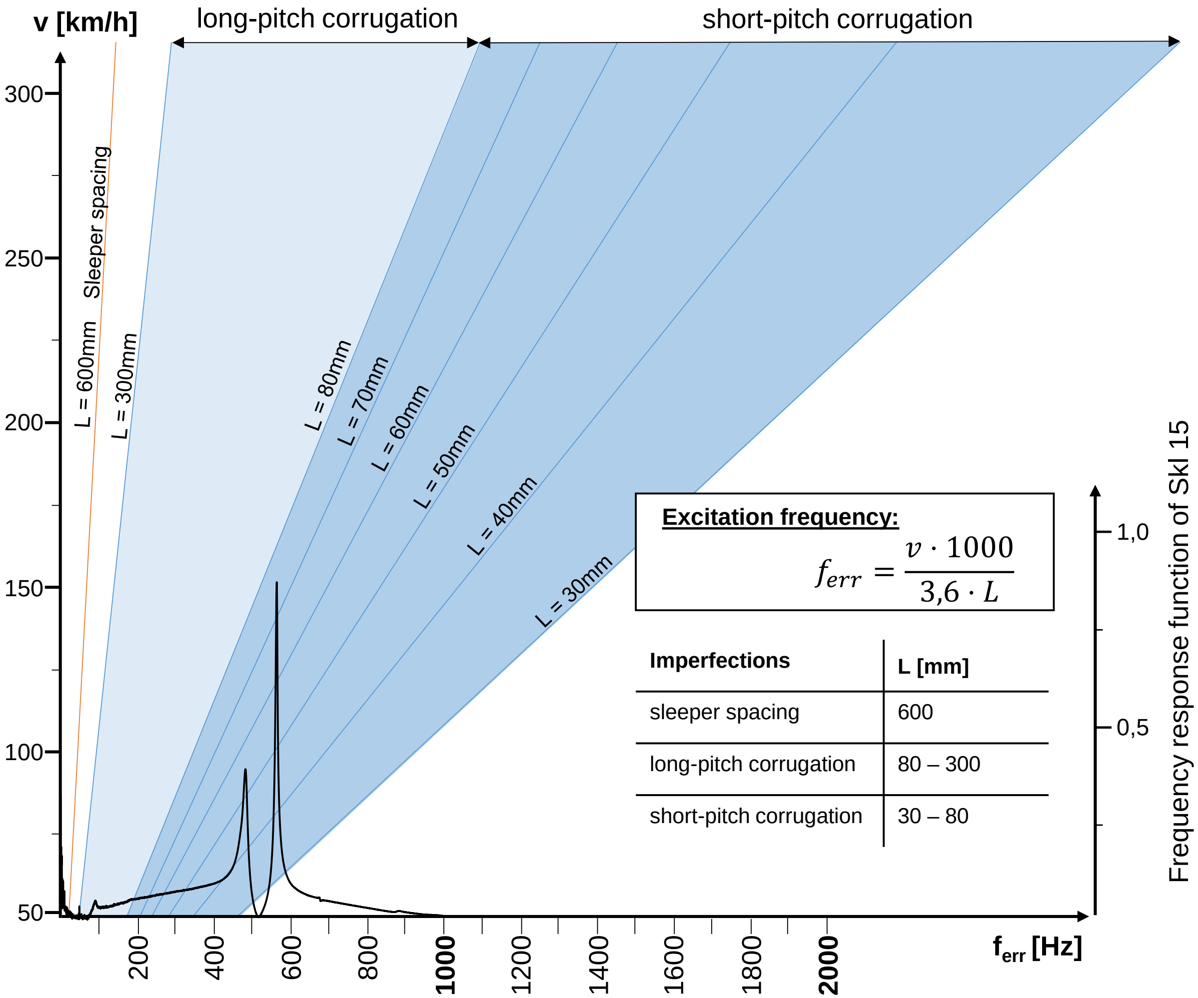


Dynamic Behavior of Skl 15 - FEA

Calibrated FEA model - First Eigenmode (570 Hz)



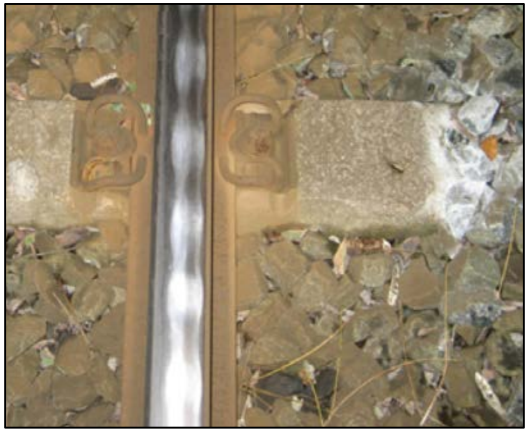
Excitation Frequencies due to Rail Defects

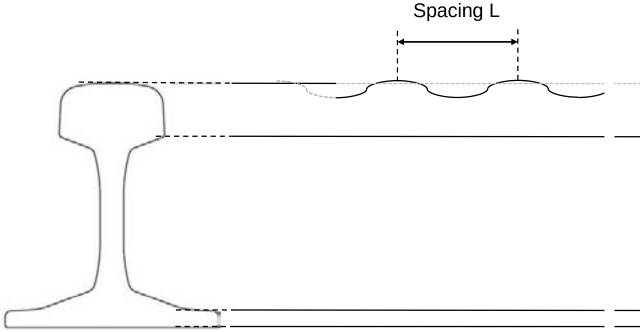


Excitation frequency:

$$f_{err} = \frac{v \cdot 1000}{3{,}6 \cdot L}$$

Imperfections	L [mm]
sleeper spacing	600
long-pitch corrugation	80 – 300
short-pitch corrugation	30 – 80





Dynamic Behavior of Skl 15 – Summary:

- Fastening clamps of the type Skl 15 have a first eigenfrequency at 570 Hz
- At the first eigenfrequency the arms of the clamps show a sliding and tilting-motion
- This eigenmode leads to additional stresses at the bending of the arms of the clamps

- Short-pitch corrugation leads to vibrations in the railway superstructure, which can match the eigenfrequencies of the railway fastening clamps

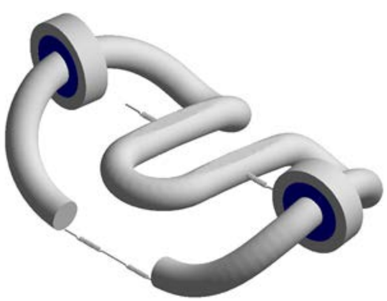
- To avoid deterioration of clamps, the project proposes different measures that influence the dynamic behavior of the railway fastening clamps

Possible Countermeasures to avoid Deterioration

Design of countermeasures based on the calibrated FEA model:

FEA Model ⇄ Lab testing

Dynamic Absorber

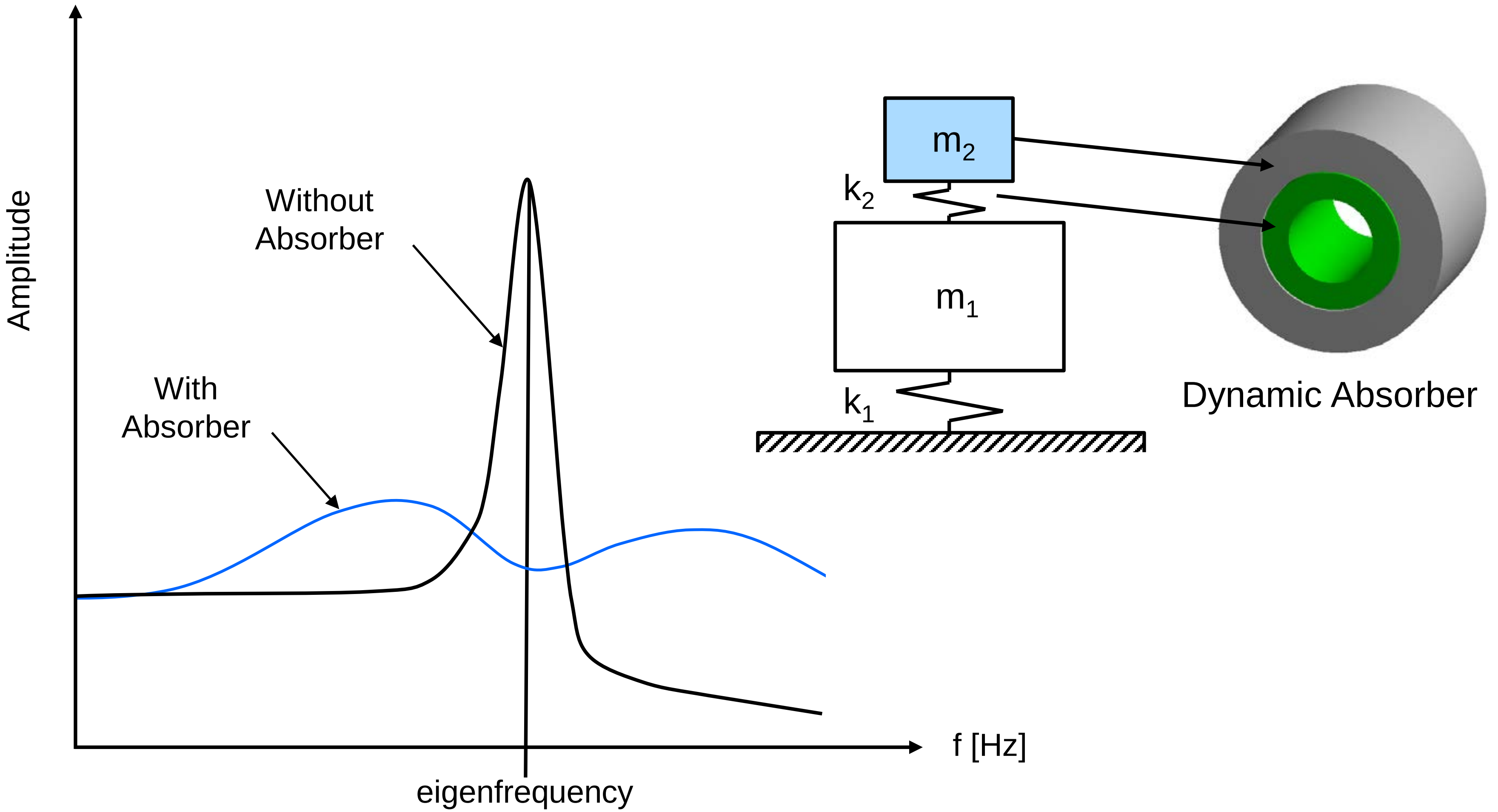


Modified Geometry

MATLAB-tool:
Optimized geometries

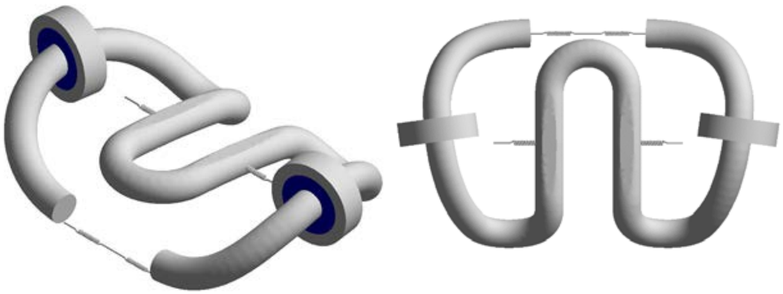
Modified Angle guiding plate

Dynamic Absorber - Theory



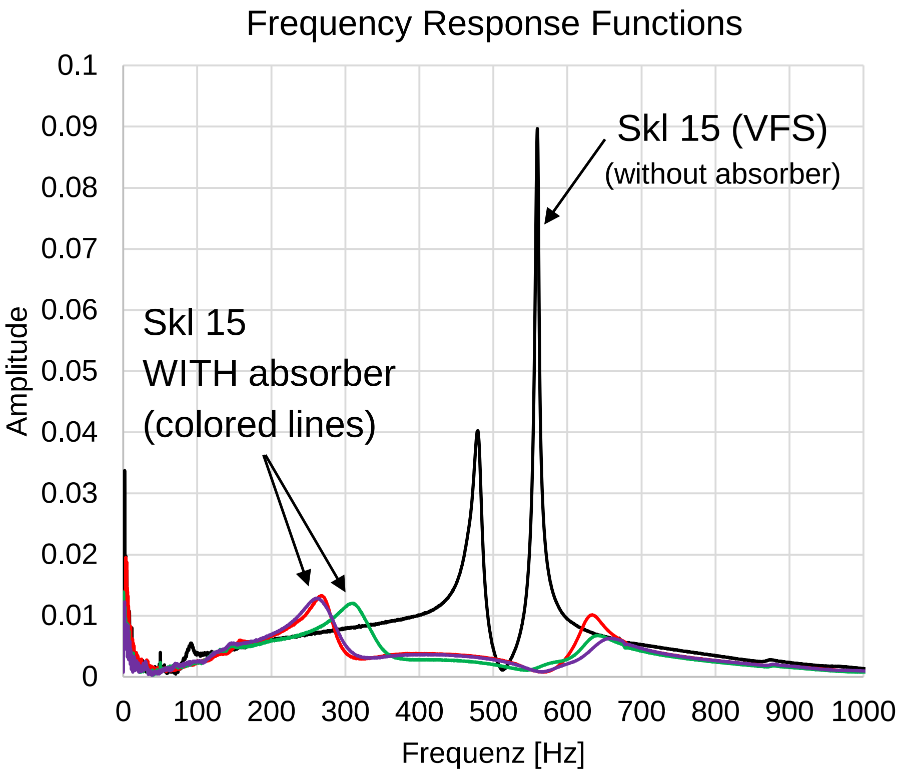
Dynamic Absorbers Neutralize Vibrations

FEA Design of vibration absorbers resulted in first prototypes



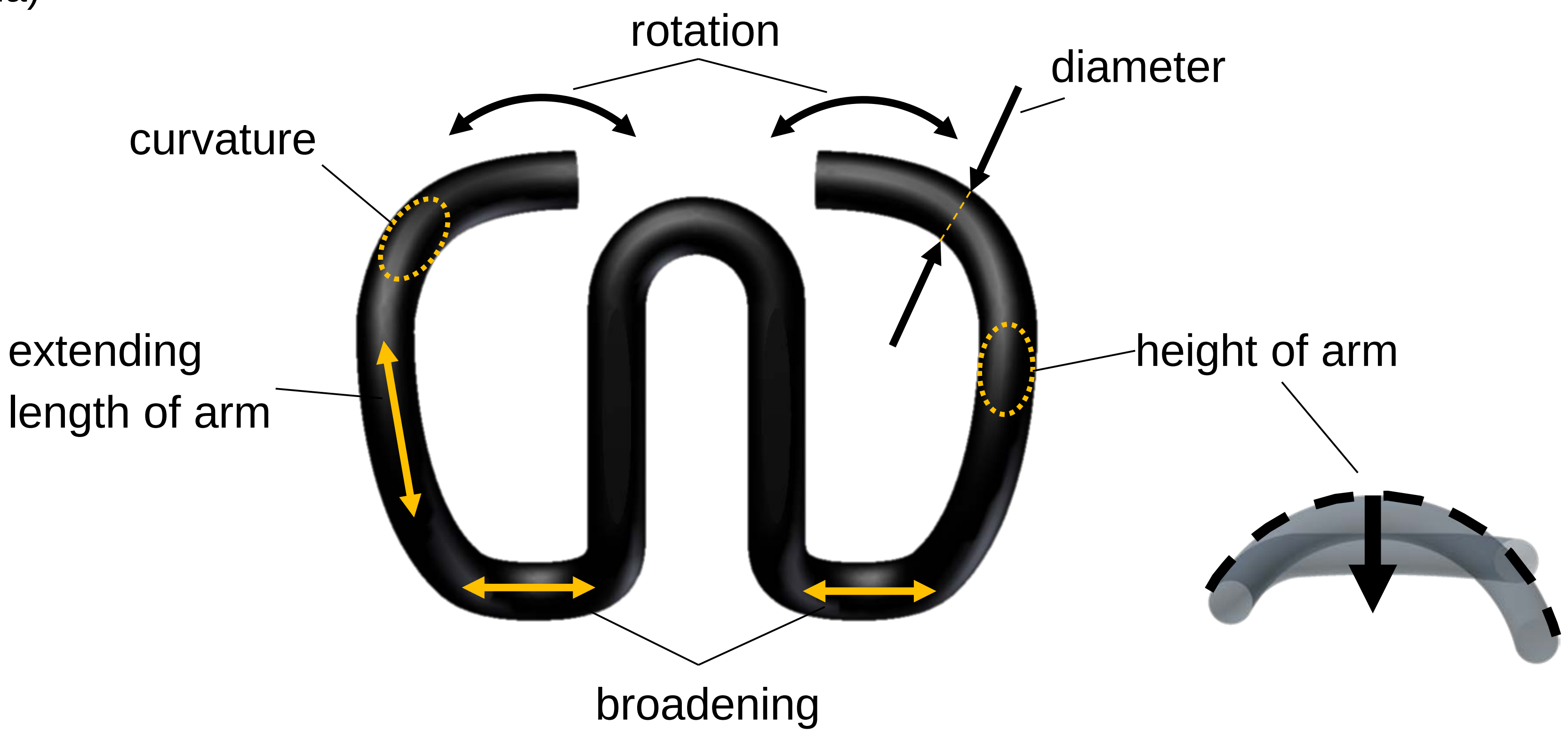
First prototypes during laboratory tests

Experimental testing in the laboratory reveals a good efficacy of the absorber elements:

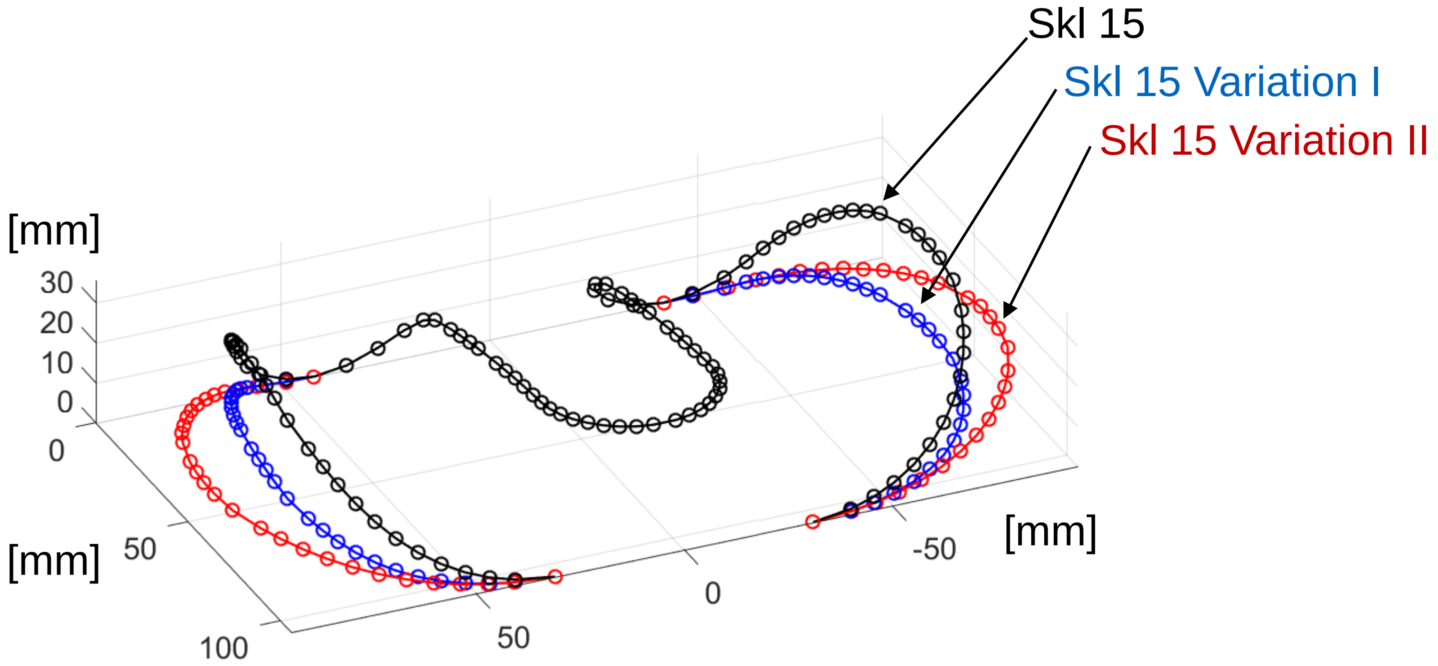


Modifications to the Geometry of Clamps

A MATLAB-tool allows us to make rapid modifications to the geometry of the clamp to optimize the dynamic behavior (increasing the first eigenfrequency by decreasing the mass moment of inertia)



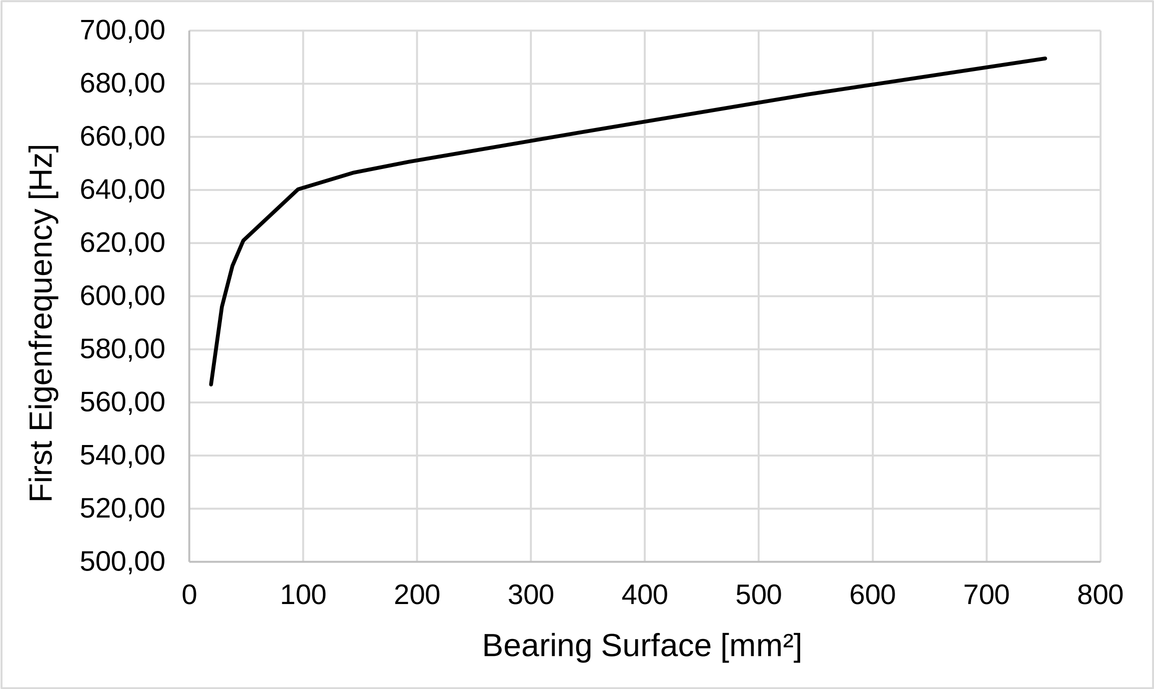
Modified Geometries Increase the Eigenfrequencies of Clamps

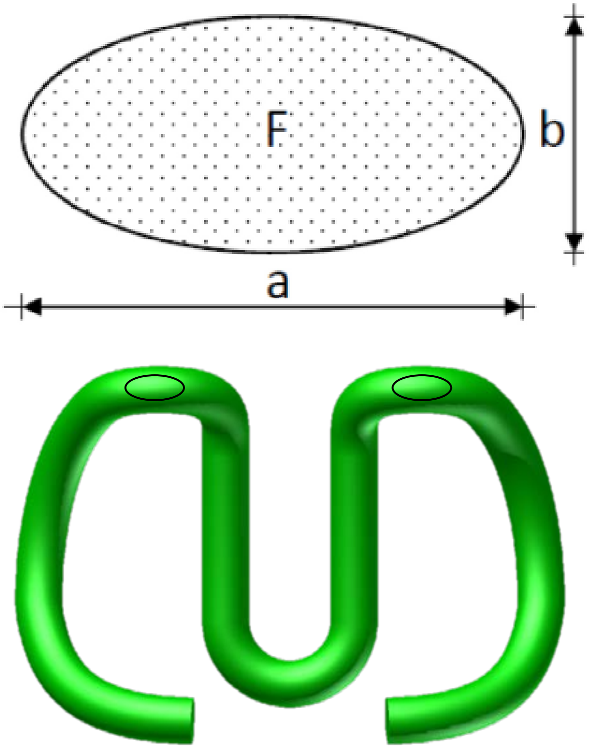


The project proposes modified geometries of fastening clamps. The new geometries lead to higher eigenfrequencies, while the spring characteristics of the clamps are maintained.

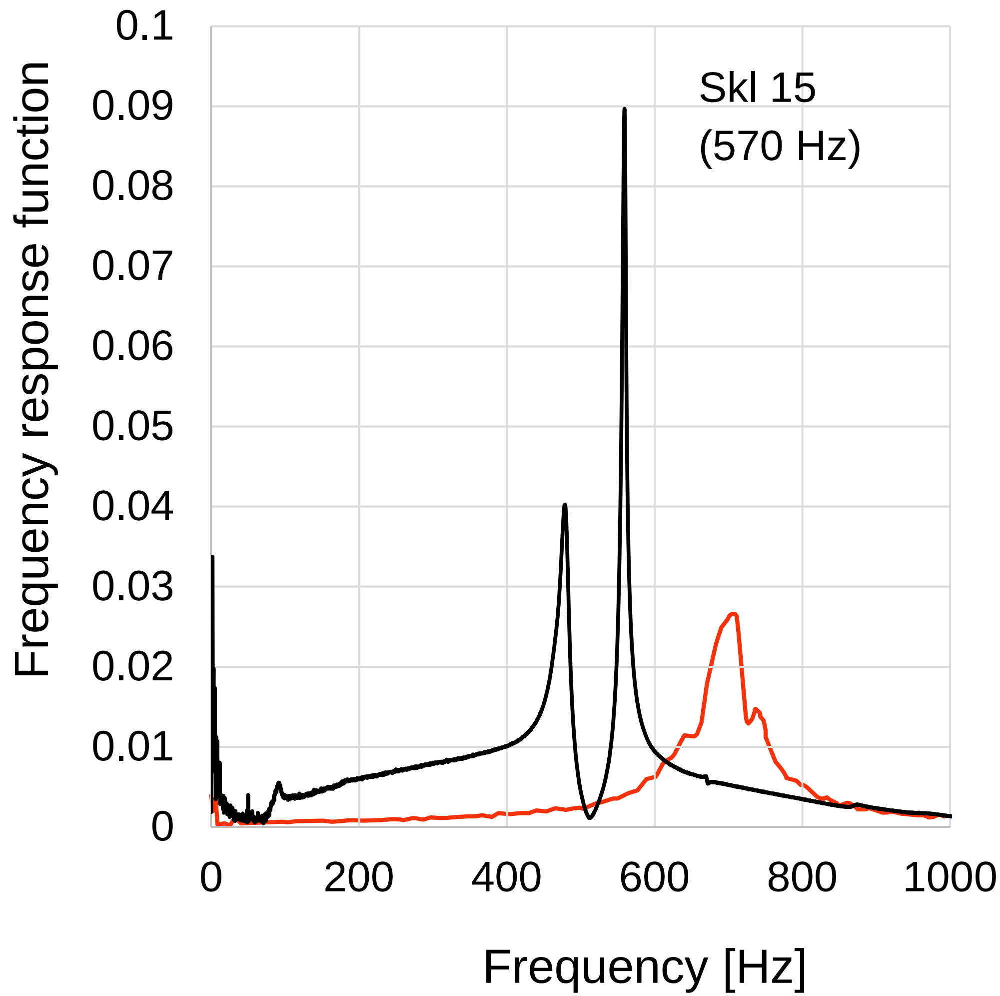
Design of a Modified Angle Guiding Plate

Increasing the bearing surface raises the eigenfrequencies



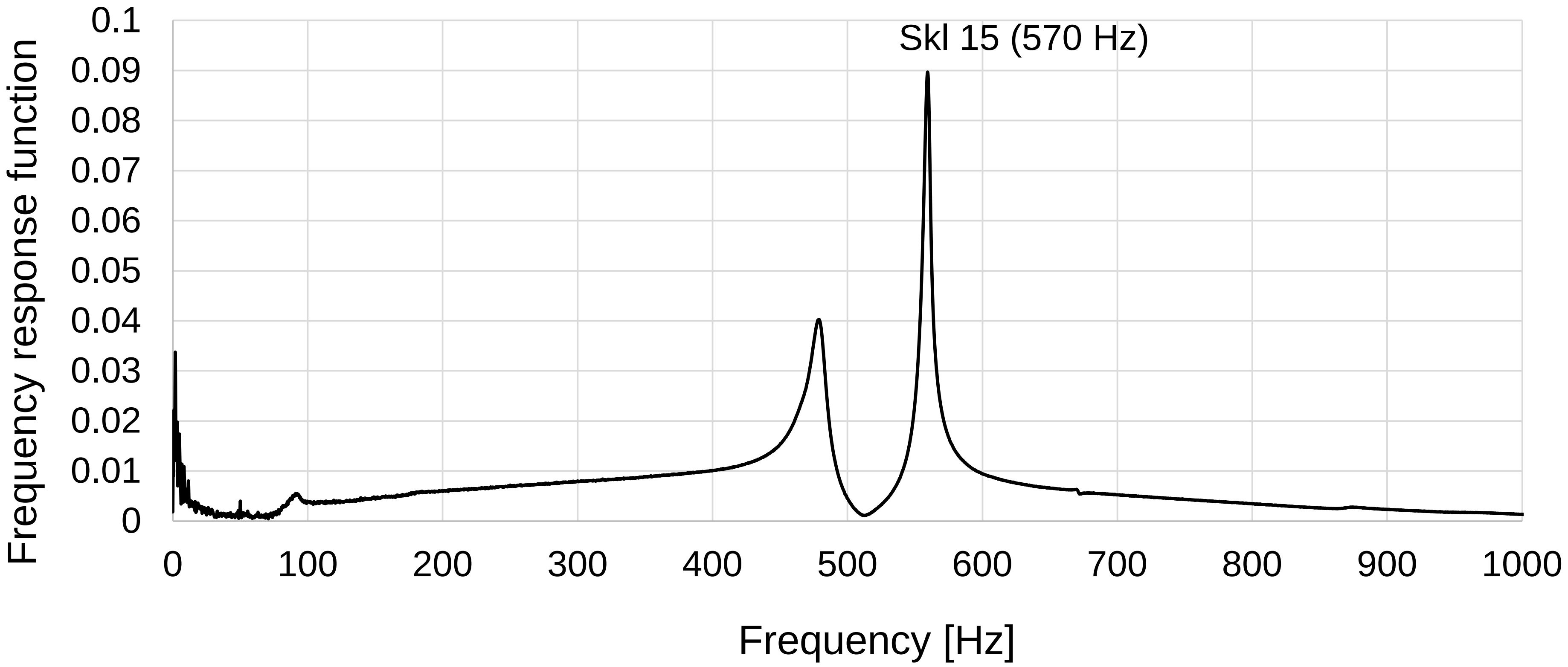


Prototype of a Modified Angle Guiding Plate



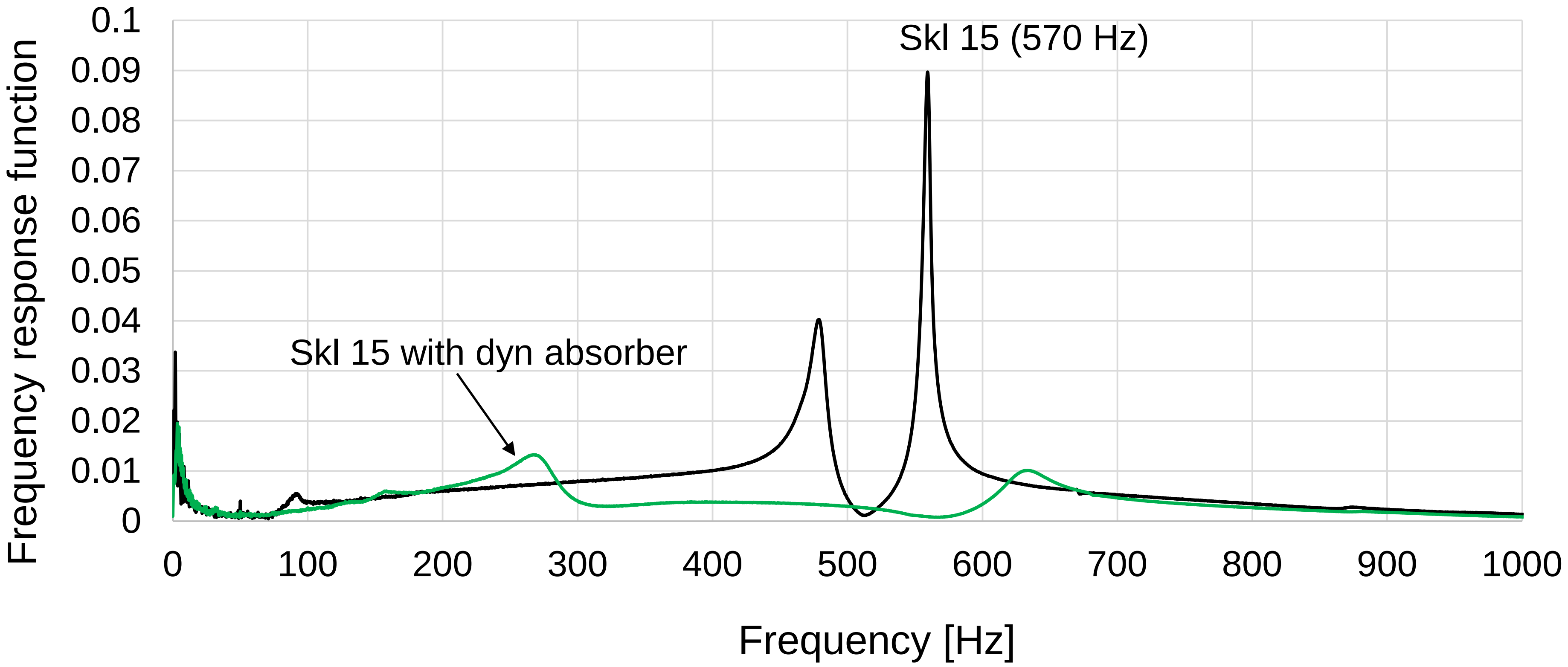
Summary – Results:

Original frequency response function of a clamp Skl 15



Summary – Results:

To avoid deterioration caused by resonance effects, different measures were proposed. All measures influence the dynamic behavior of the clamps and showed a good efficacy in lab testing and simulation.



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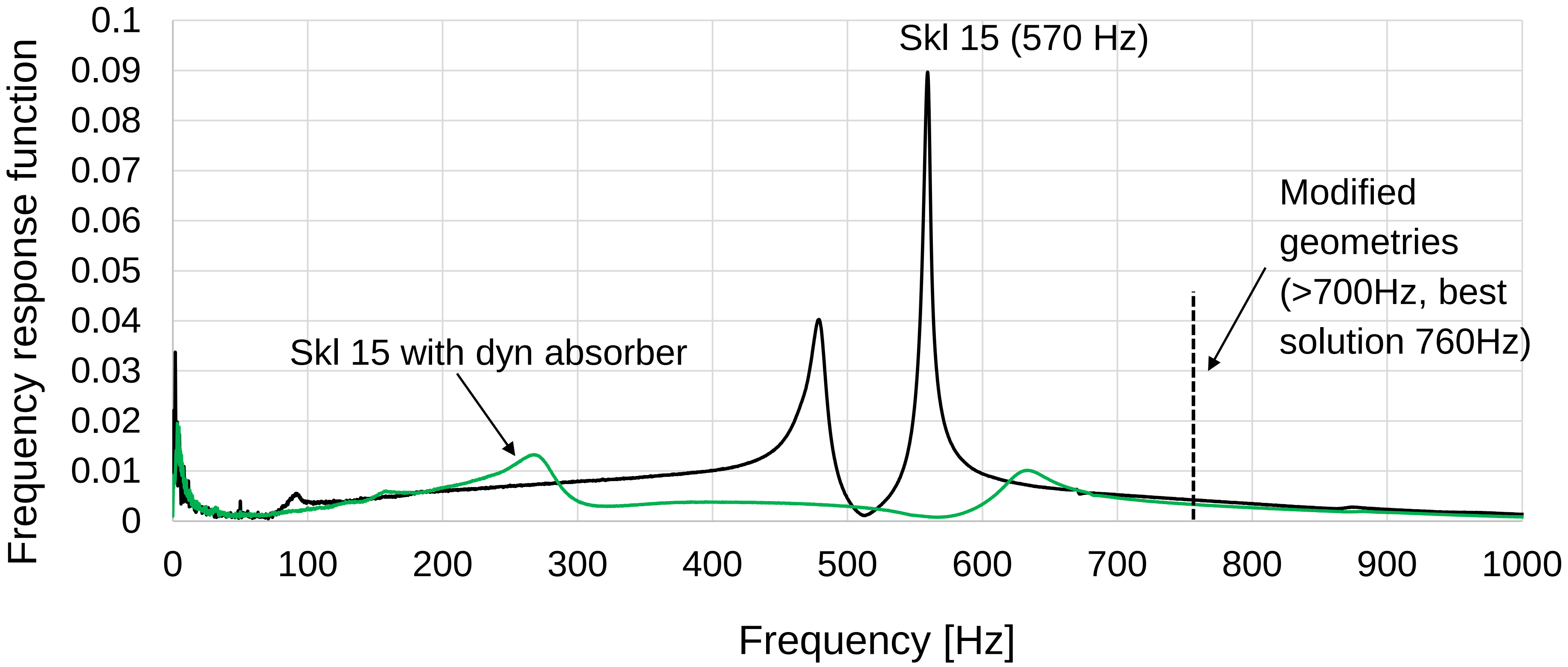

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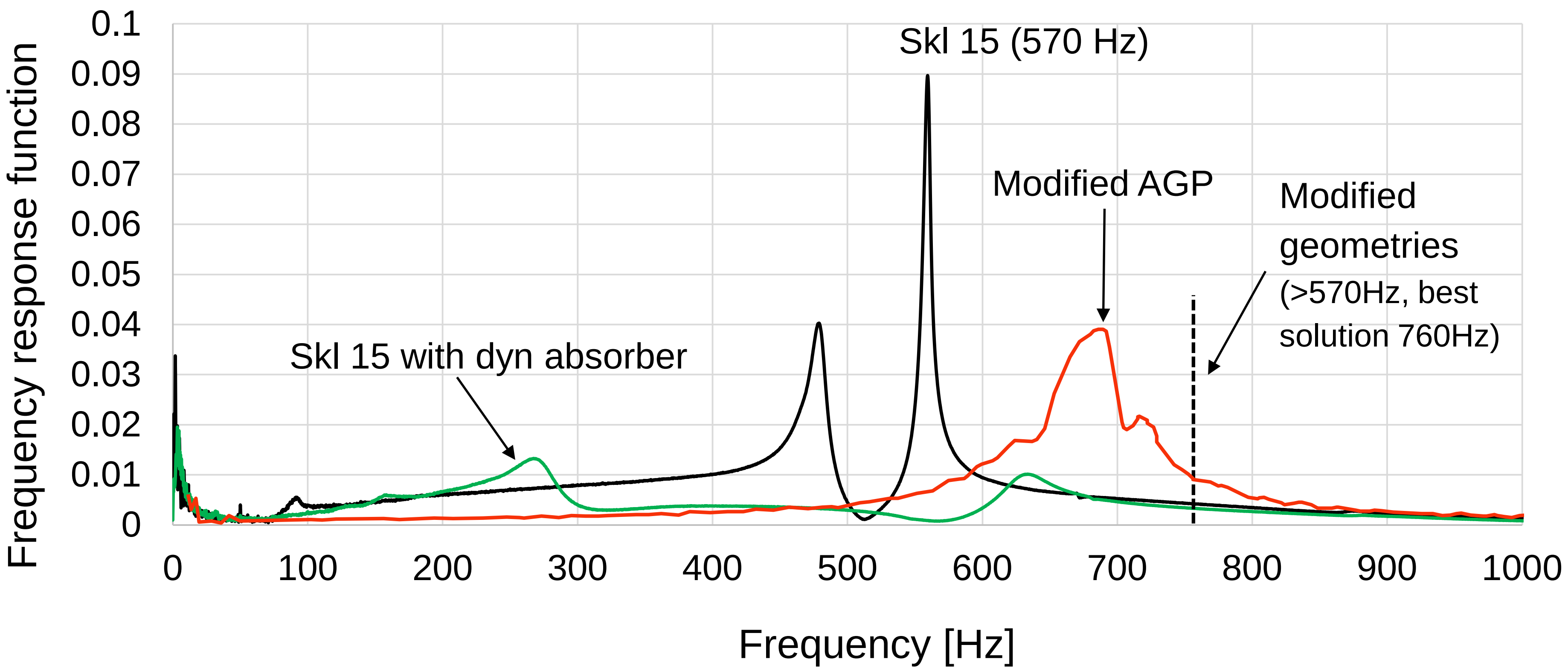

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Questions?

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