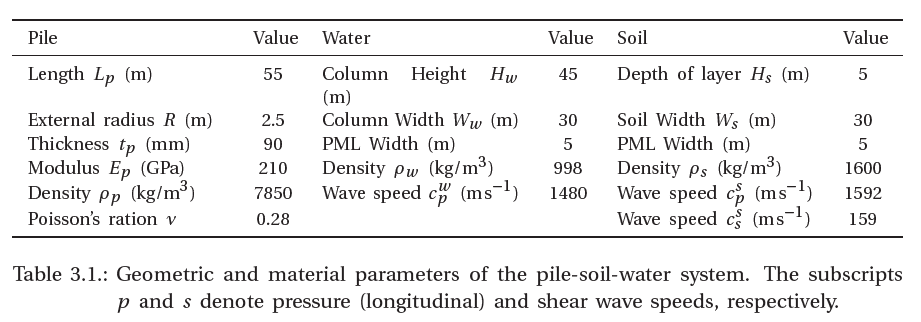
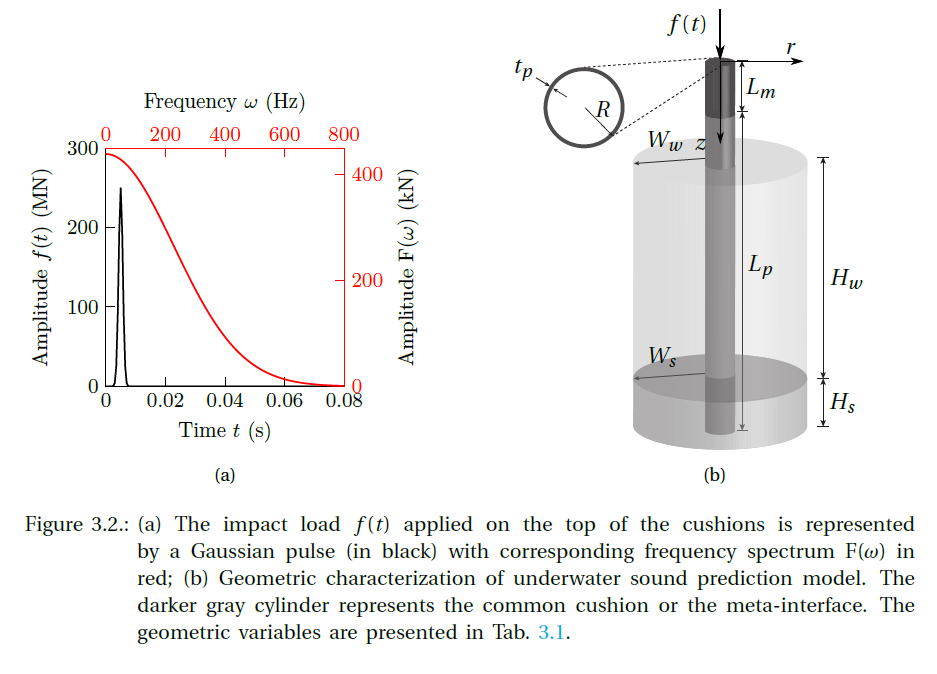
This file contains the figures exhibiting the numerical and experimental results developed during the PhD project: *Design methodology for a metamaterial-based cushion for reducing underwater noise from impact-driven offshore monopiles*. The data related to the figures are found in the mat files in this repository.

Author: Ana Carolina Azevedo Vasconcelos

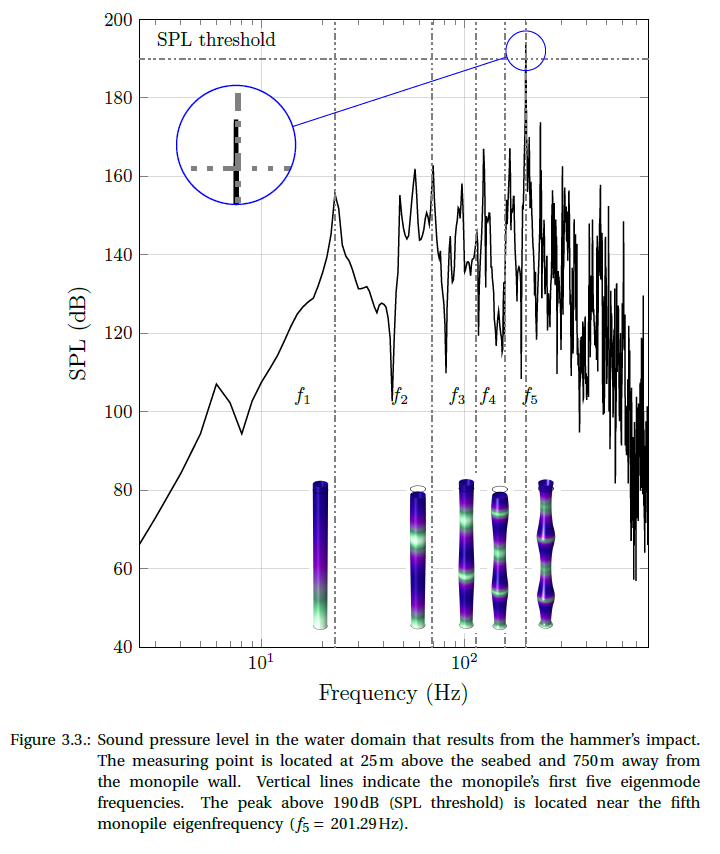
**Chapter 3**

**Input parameters:**

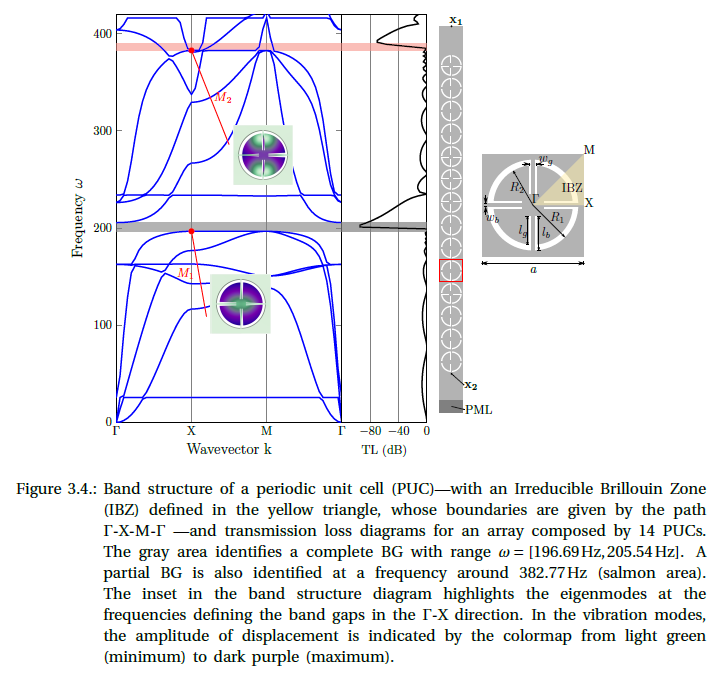
****

****

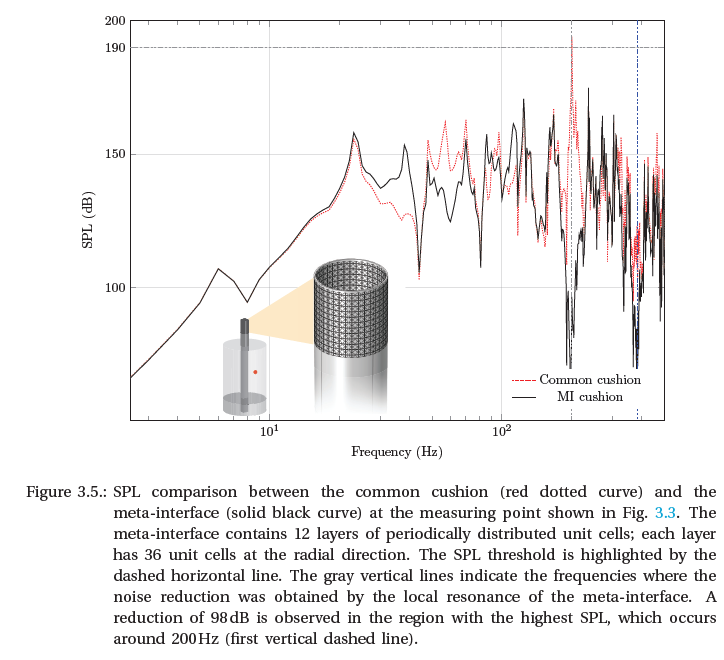
**Figure 3.2 Time signal and frequency spectrum of impact load applied in the numerical model exhibited in (b).**

****

**Figure 3.3 Sound pressure level obtained through a time-harmonic analysis simulation of the pile system.**

****

**Figure 3.4 Dispersion curves and transmission loss obtained through eigenfrequency studies of the periodic unit cell and time-harmonic simulations of the finite unit cell array, respectively.**

****

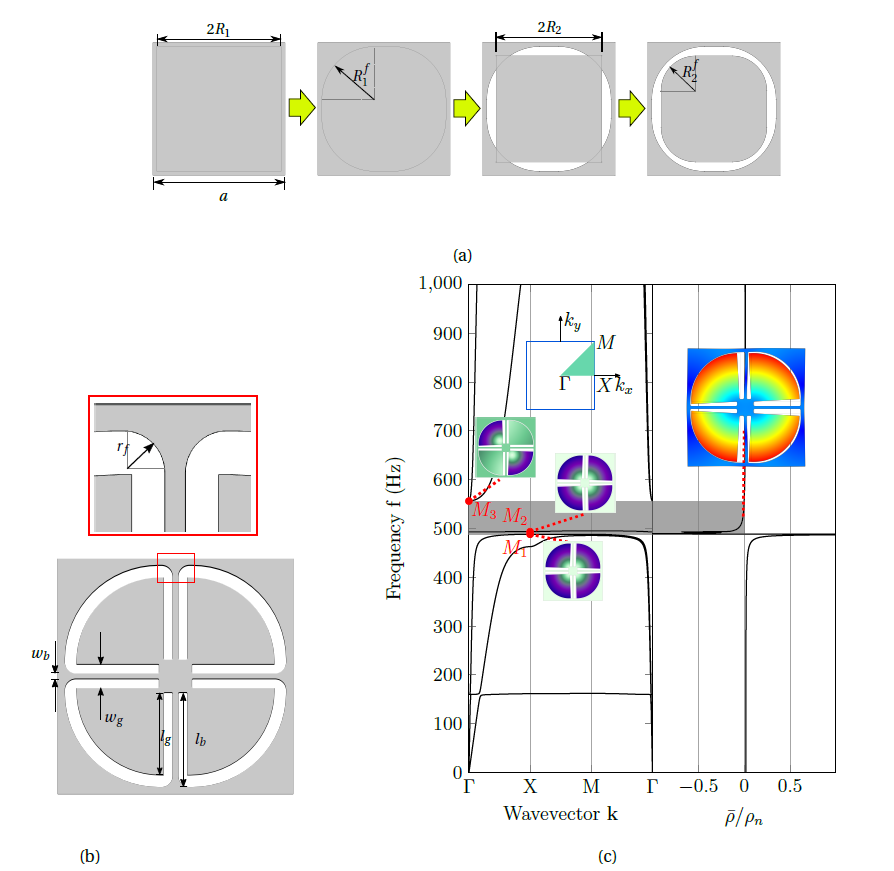
**Figure 3.5 Sound pressure level after including the meta-cushion in the pile system.**

**Chapter 4**

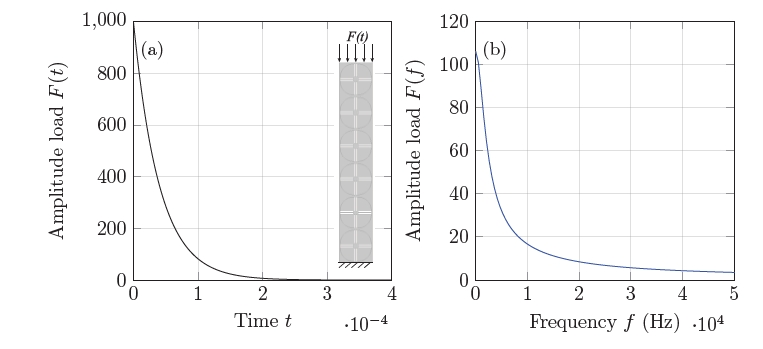
**Input parameters:**

Reference unit cell specifications (see Fig. 4.1 for geometric parameters definition):

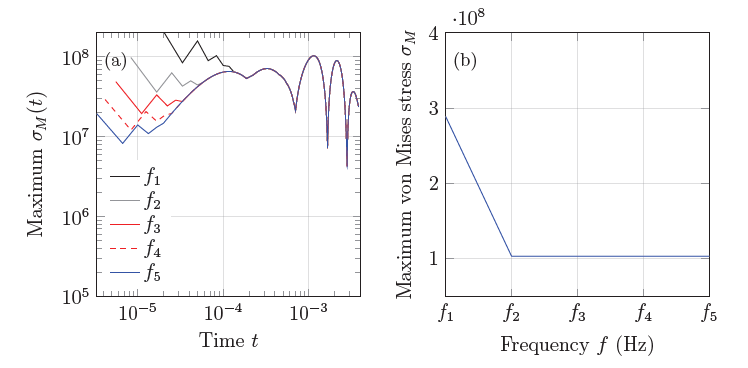
|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| a | R1 | R2 | wb | lg | lg | lb | R1f | R2f | rf | tc |
| 0.042 m | 0.47\*a | 0.46\*a | 1 mm | 0.07\*a | 0.1\*a | R2-lg | 0.85\*R1 | 0.85\*R2 | 0.5 mm | 10 mm |



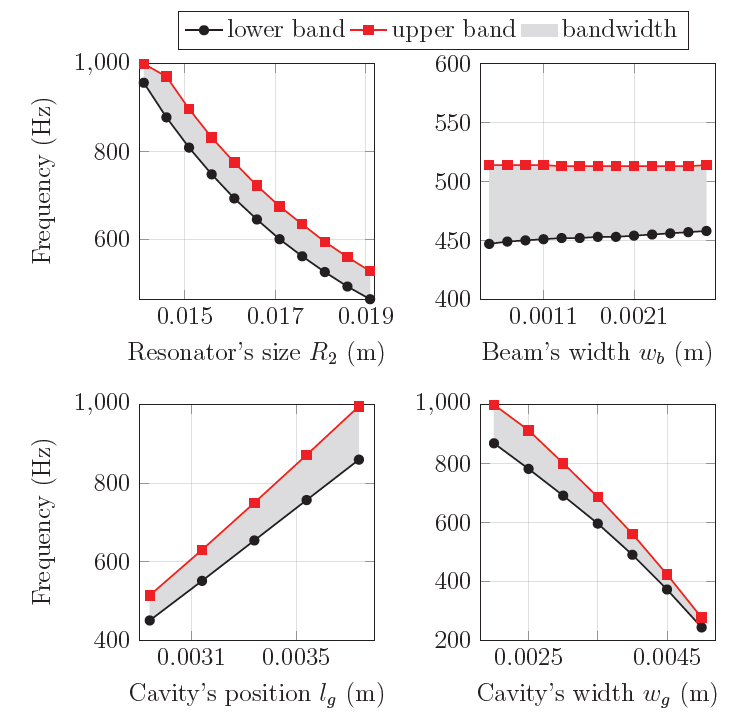
**Figure 4.1 Geometric parameters of reference unit cell. (c) Band structure and effective mass density obtained through eigenfrequency analysis and time-harmonic simulations, respectively.**

****

**Figure 4.2 (a) Time signal and (b) frequency spectrum of impact load**

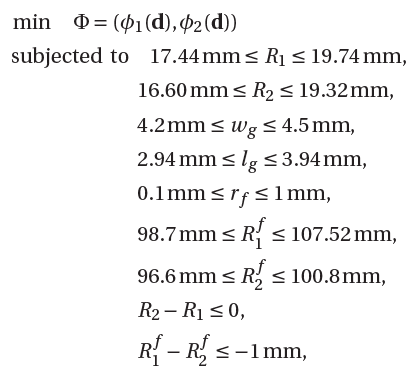
****

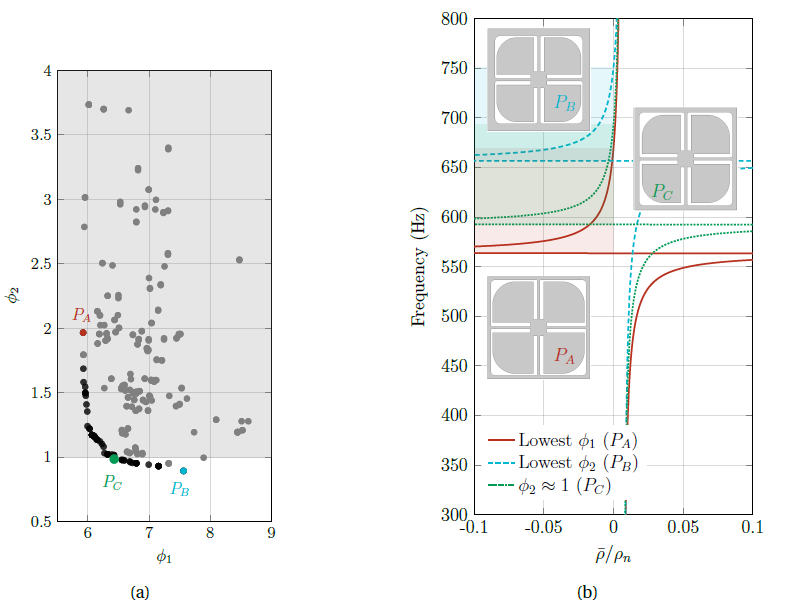
**Figure 4.3 (a) Maximum Von Mises stress over time for different frequencies and (b) peak Von Mises stress obtained in each transient simulation.**

****

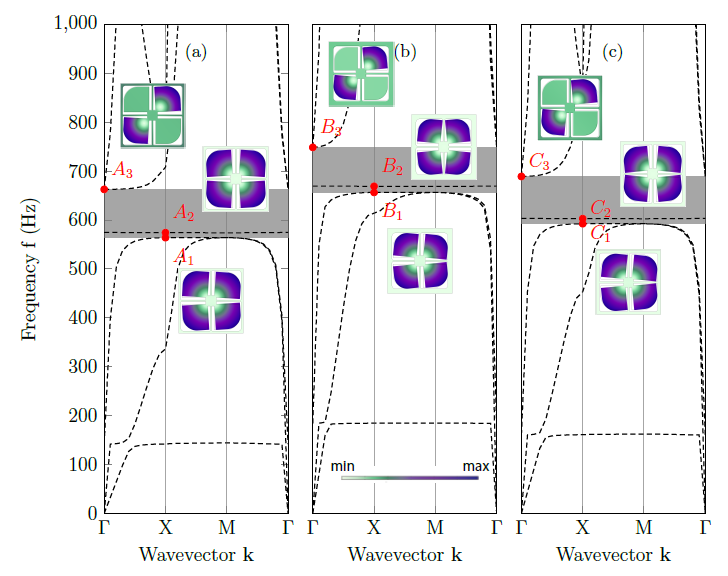
**Figure 4.4 Variation of the bandwidth and central frequency of the band gap obtained through time-harmonic simulations.**

**Optimization constraints for multi-objective optimization via genetic algorithm:**

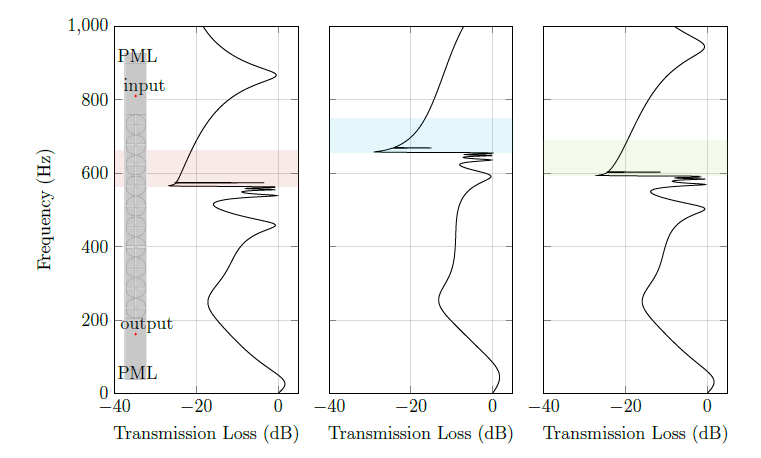
****

****

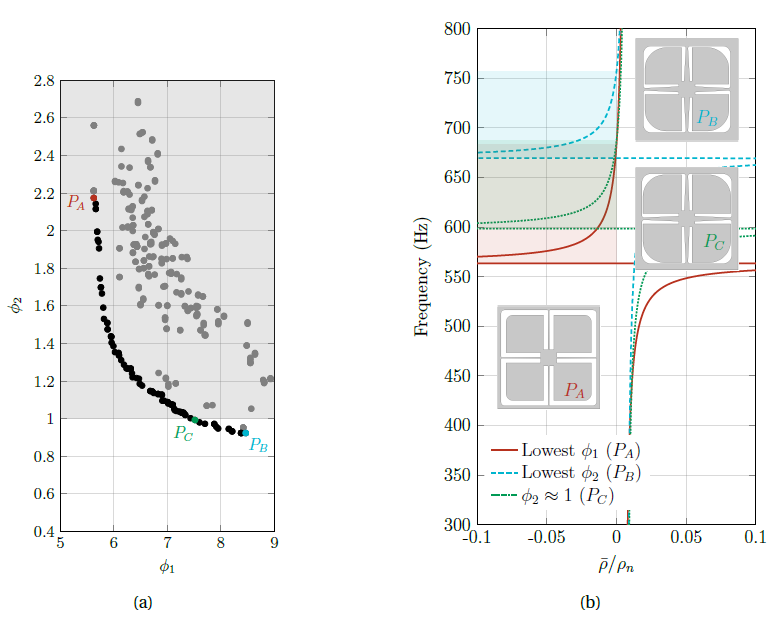
**Figure 4.6 (a) Pareto front and (b) verification of band gaps of points PA, PB, and PC.**

****

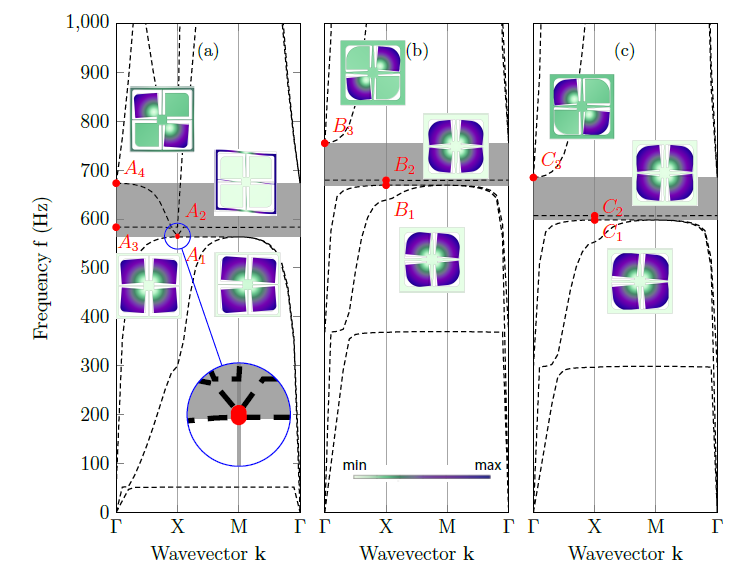
**Figure 4.7 Dispersion curves of unit cells (a) PA, (b) PB, and (c) PC.**

****

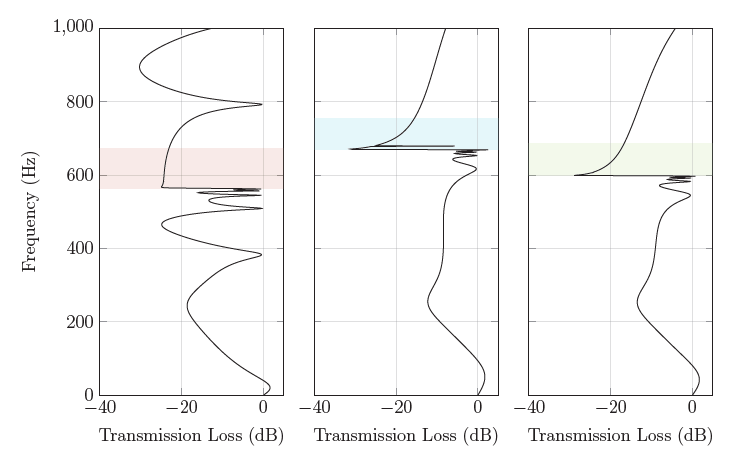
**Figure 4.8 Transmission loss of arrays containing unit cells (a) PA, (b) PB, and (c) PC.**

****

**Figure 4.10 Multi-objective optimization for unit cells containing non-uniform beams. (a) Pareto front and (b) verification of band gaps of points PA, PB, and PC.**

****

**Figure 4.11 Dispersion curves of unit cells (a) PA, (b) PB, and (c) PC obtained in Figure 4.10.**

****

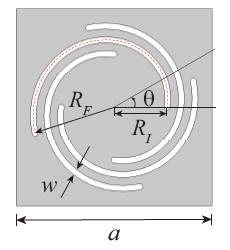
**Figure 4.13 Transmission loss of arrays containing unit cells (a) PA, (b) PB, and (c) PC o obtained in Figure 4.10.**

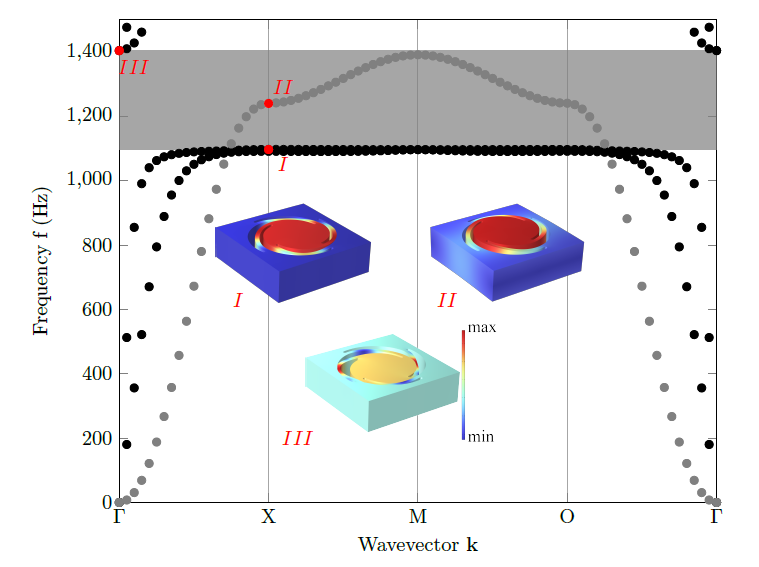
**Chapter 5**

**Input parameters:**

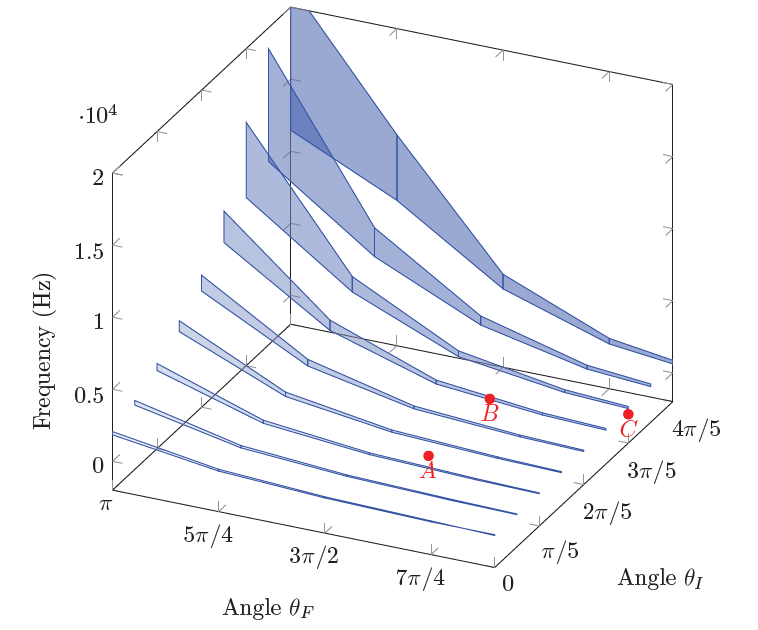
Reference unit cell specifications as shown below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| a | RI | RF | θI | ΘF | nt | w |
| 0.04 m | 8 mm | 17 mm | 3π/5 | 8π/5 | 0.8 | 1.2 mm |

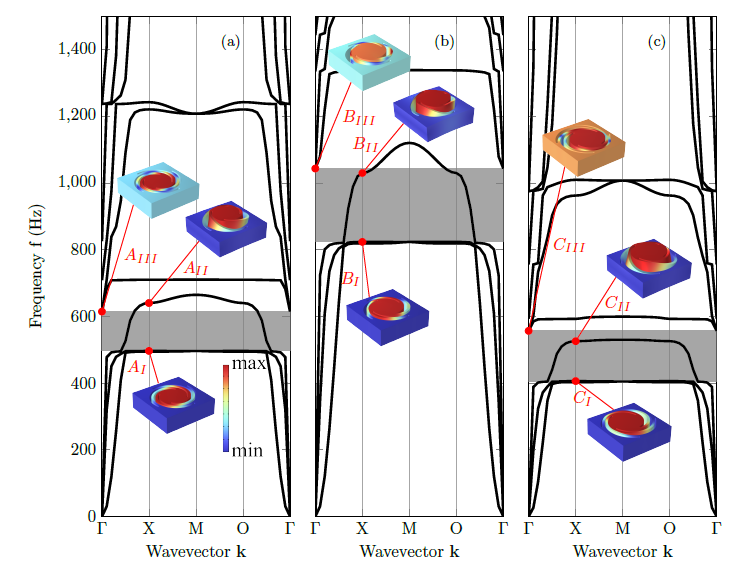
****

****

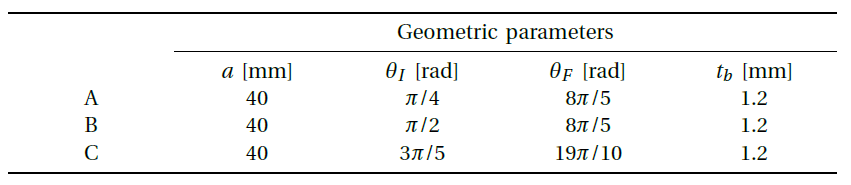
**Figure 5.2 Dispersion curves of the reference unit cell obtained through an eigenfrequency analysis.**

****

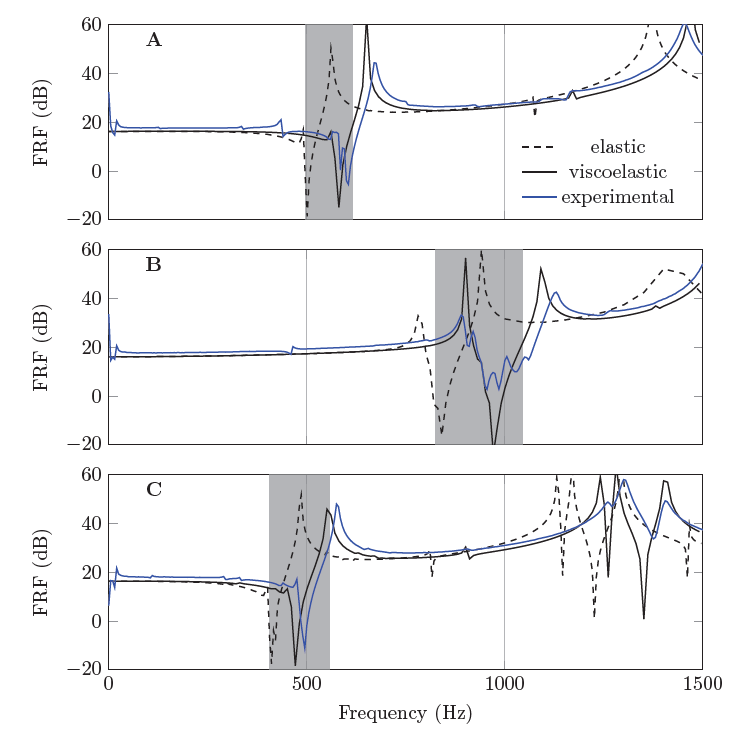
**Figure 5.3 Band gaps obtained through parametric sweep of eigenfrequency analyses.**

****

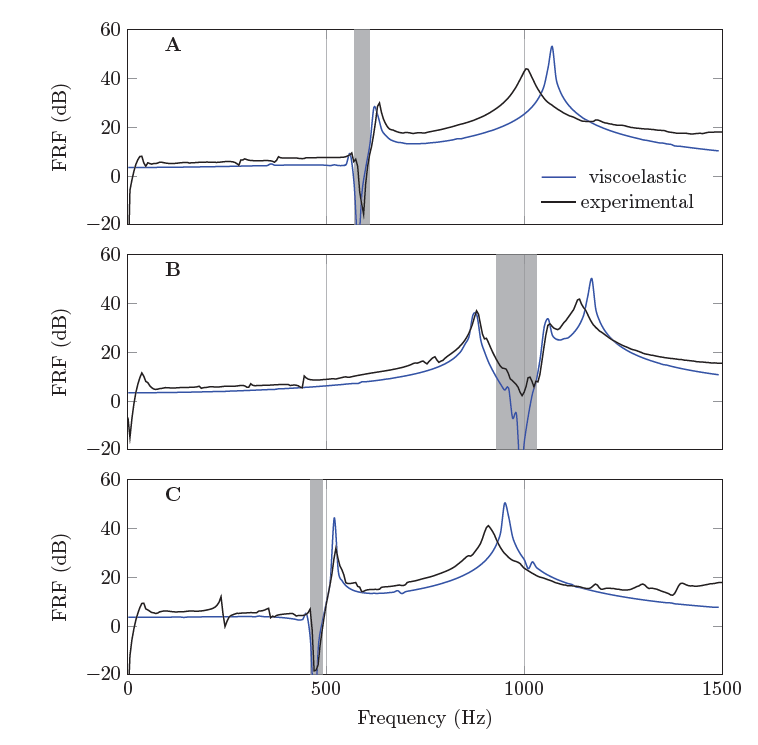
**Figure 5.4 Dispersion curves of unit cells with geometric parameters described in the table below.**

****

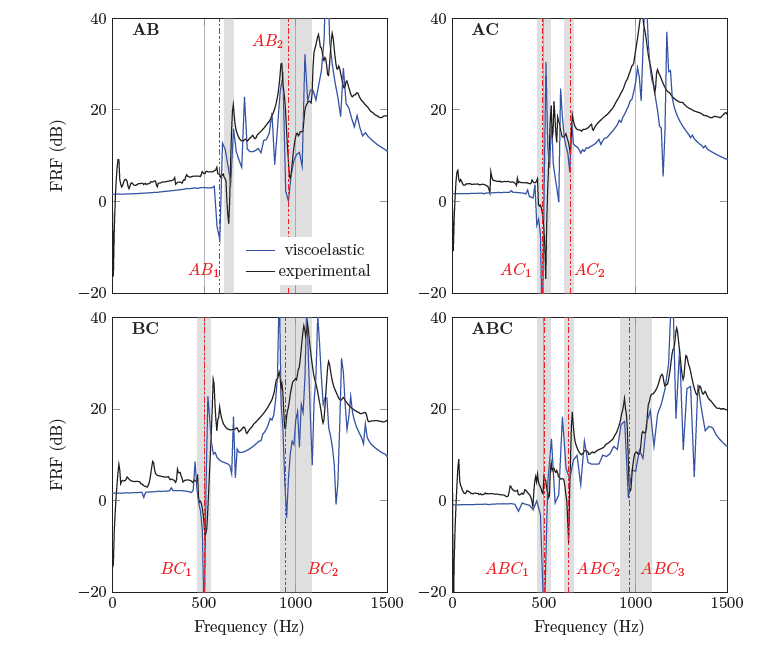
**Table 5.1 Geometric features of spiral unit cells A, B, and C.**

****

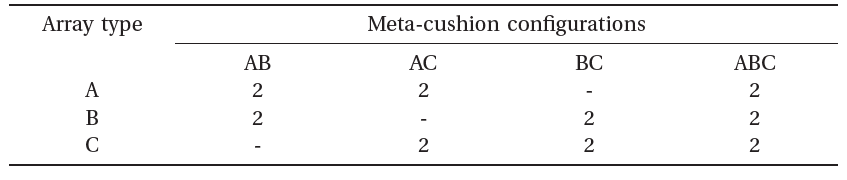
**Figure 5.7 Comparison between numerical and experimental analyses of spiral unit cells A, B, and C.**

****

**Figure 5.8 Comparison between numerical and experimental analyses of meta-cushions formed by spiral arrays of type A, B, and C.**

****

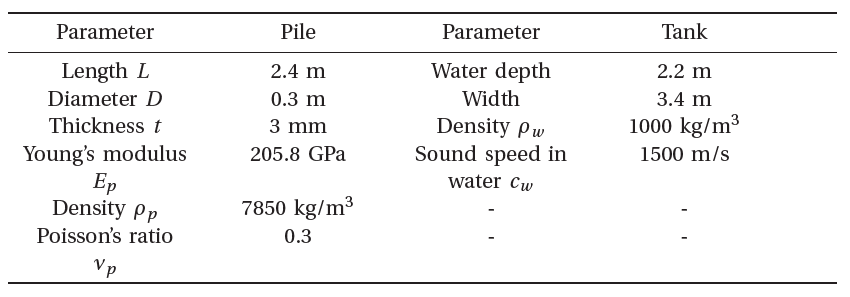
**Figure 5.10 Comparison between numerical and experimental analyses of meta-cushions with combined configurations as indicated in red text and explained in Table 5.2.**

****

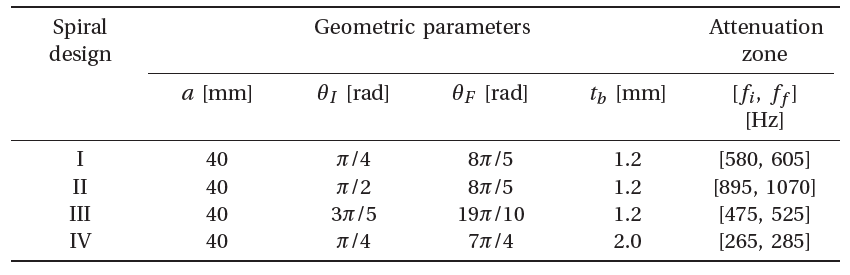
**Table 5.2 Meta-cushion configurations.**

**Chapter 6**

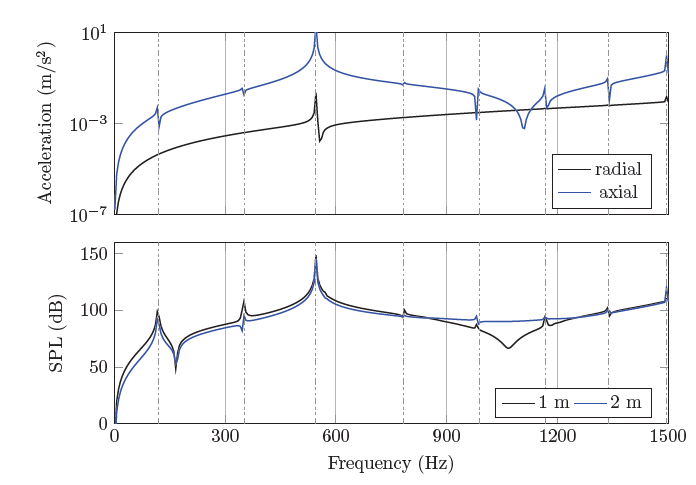
**Input parameters:**

****

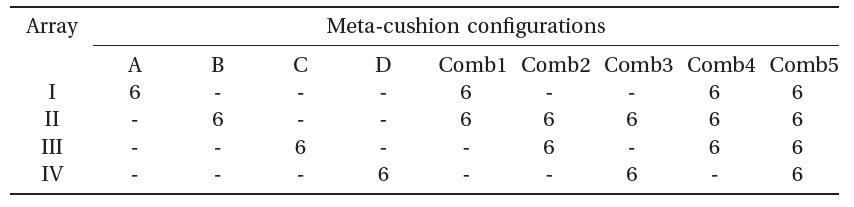
**Table 6.1 Geometric and material parameters of scaled monopile.**

****

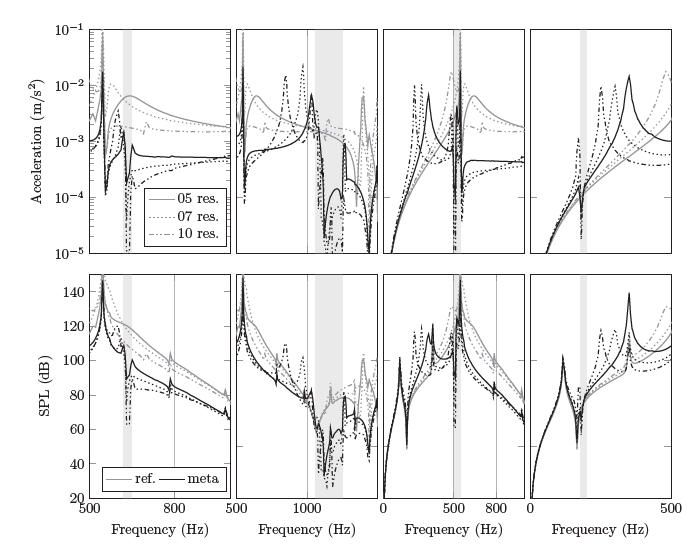
**Table 6.2 Geometric parameters of selected spiral resonator designs.**

****

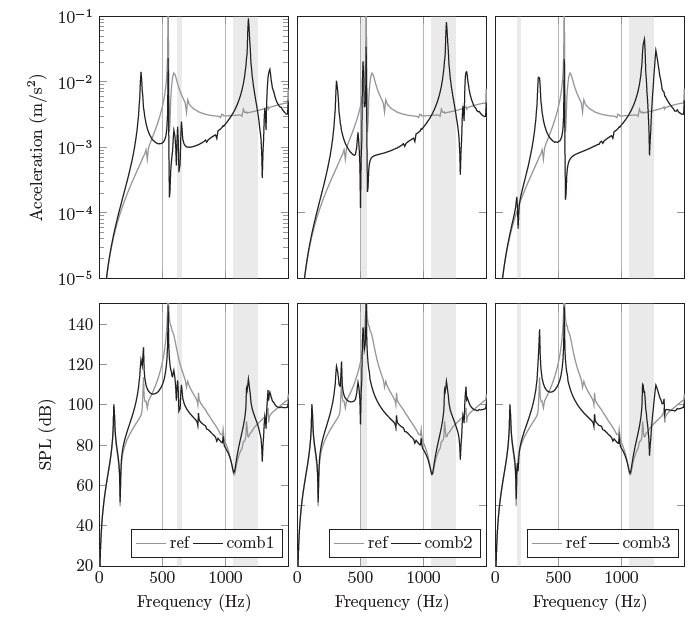
**Figure 6.3 Acceleration and sound pressure levels of numerical vibro-acoustic model.**

****

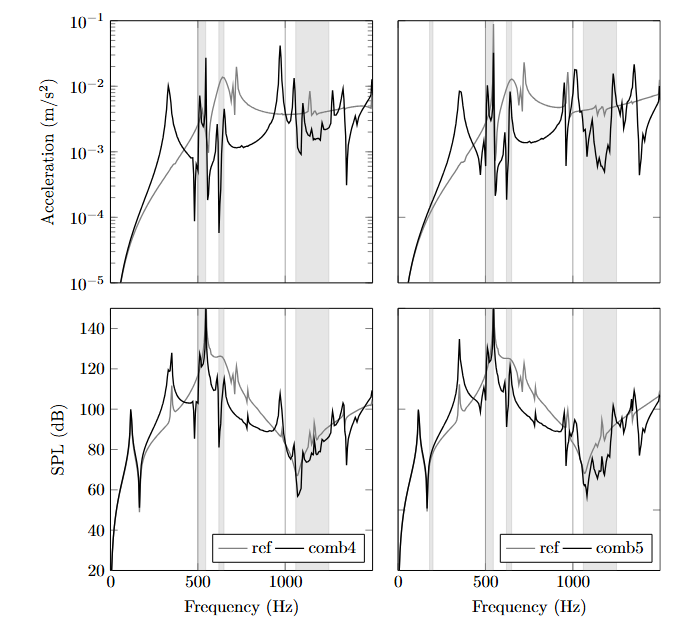
**Table 6.3 Meta-cushion configurations. The number six indicates the amount of arrays included in each configuration.**

****

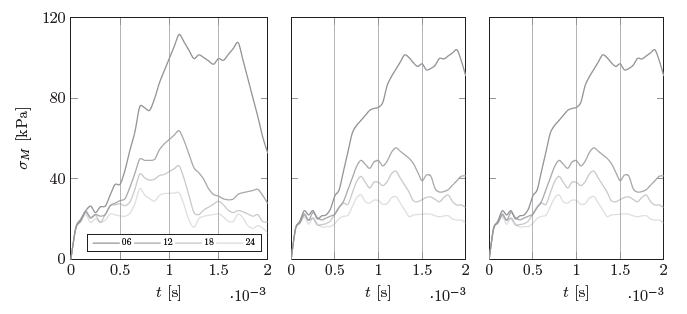
**Figure 6.4 Acceleration and sound pressure levels of numerical vibro-acoustic model containing meta-cushion configurations A to D (from left to right)**

****

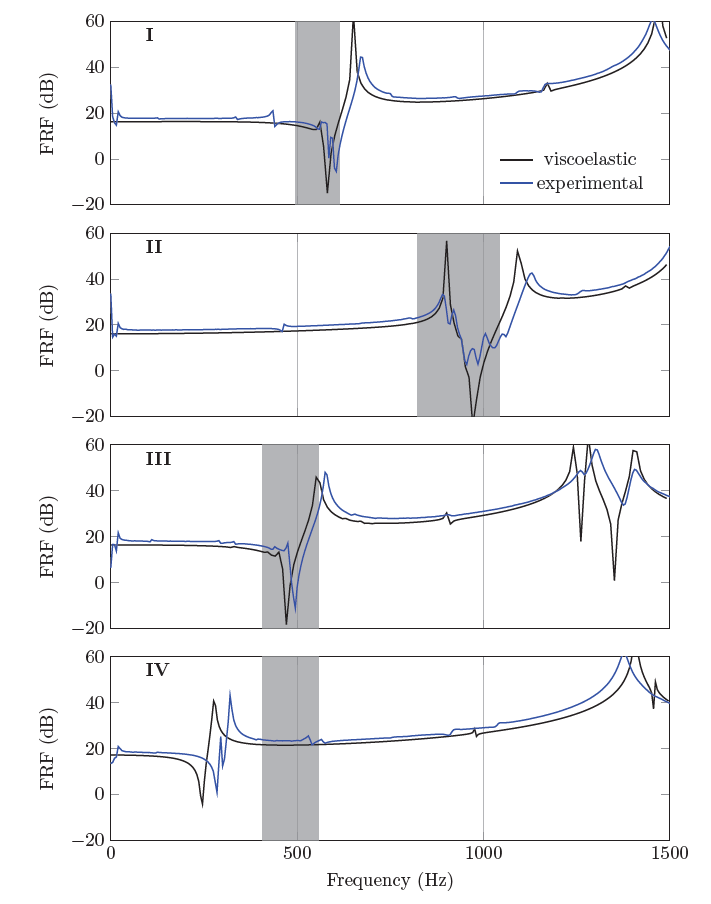
**Figure 6.5 Acceleration and sound pressure levels of numerical vibro-acoustic model containing meta-cushion configurations comb1 to comb3 (from left to right).**

****

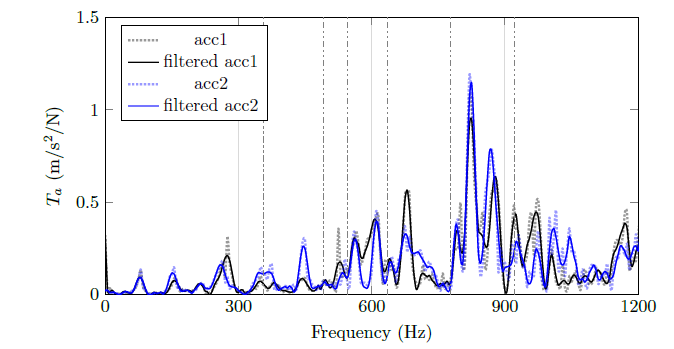
**Figure 6.6 Acceleration and sound pressure levels of numerical vibro-acoustic model containing meta-cushion configurations comb4 to comb5 (from left to right).**

****

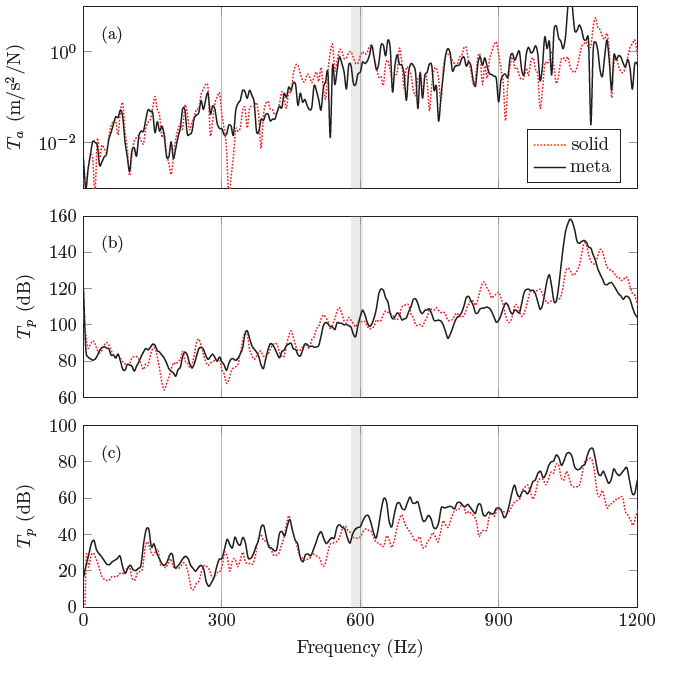
**Figure 6.7 Time history of maximum Von Mises stress for each configuration of meta-cushion containing 5 (left), 7 (middle), and 10 (right) resonators per array.**

****

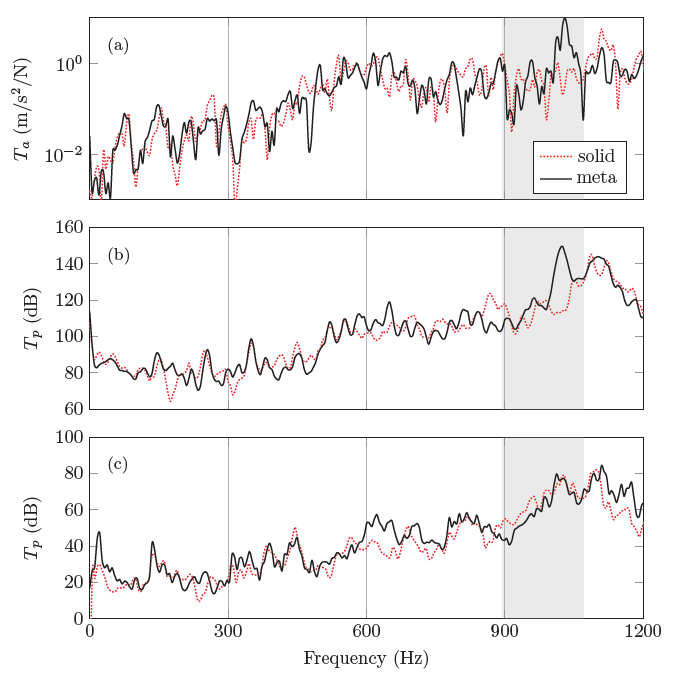
**Figure 6.11 Comparison between numerical and experimental results of spiral arrays I to IV.**

****

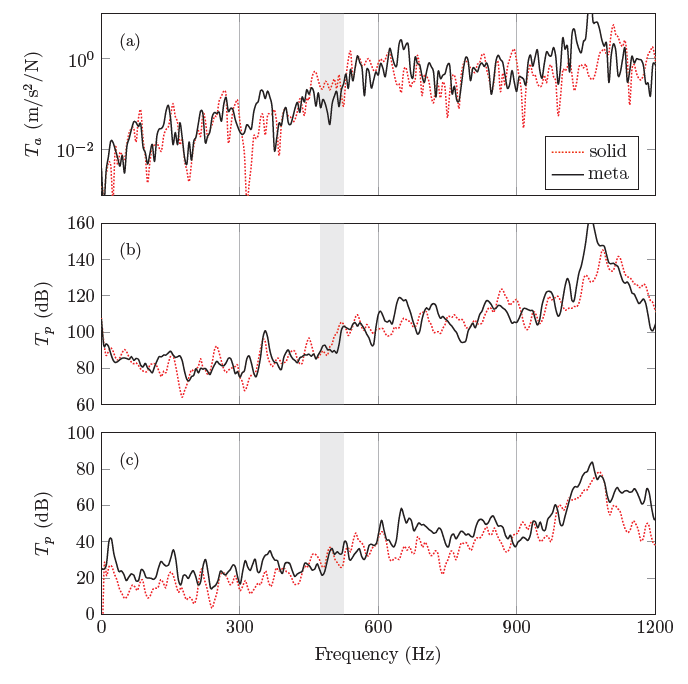
**Figure 6.13 Radial acceleration of the monopile obtained experimentally via accelerometers acc1 and acc2.**

****

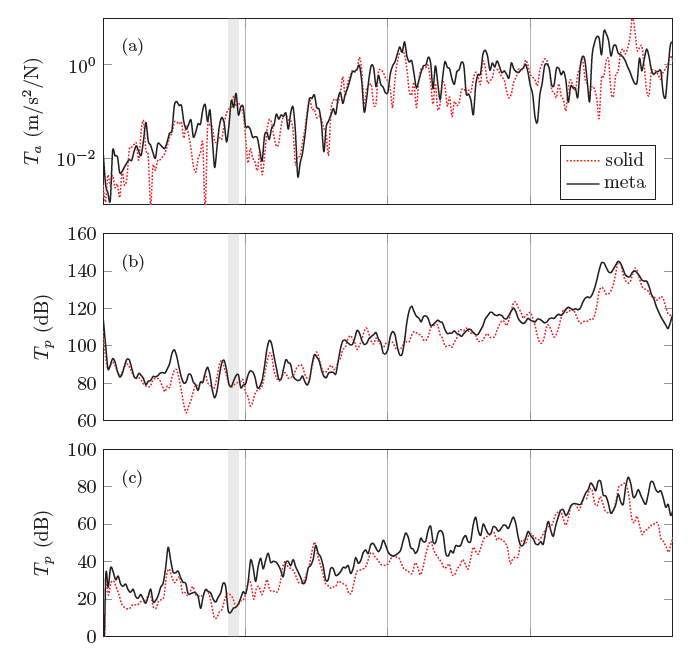
**Figure 6.14 Comparison between transfer functions obtained by hammering a monopile containing a reference cushion and a cushion A.**

****

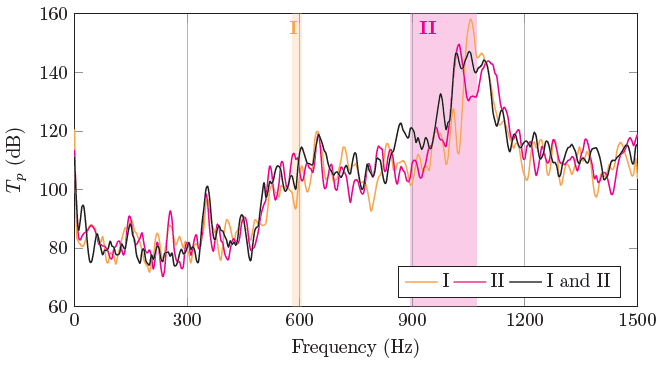
**Figure 6.15 Comparison between transfer functions obtained by hammering a monopile containing a reference cushion and a cushion B.**

****

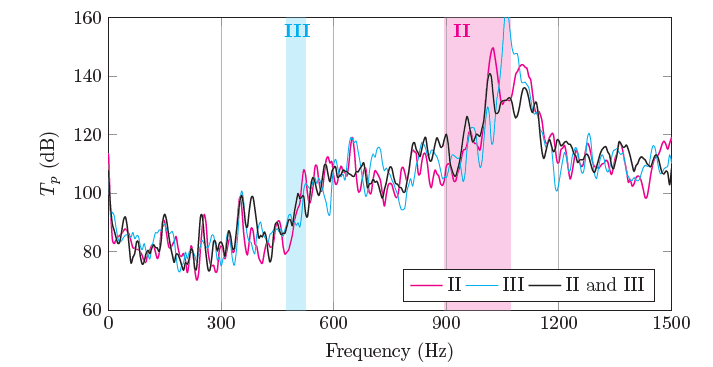
**Figure 6.16 Comparison between transfer functions obtained by hammering a monopile containing a reference cushion and a cushion C.**

****

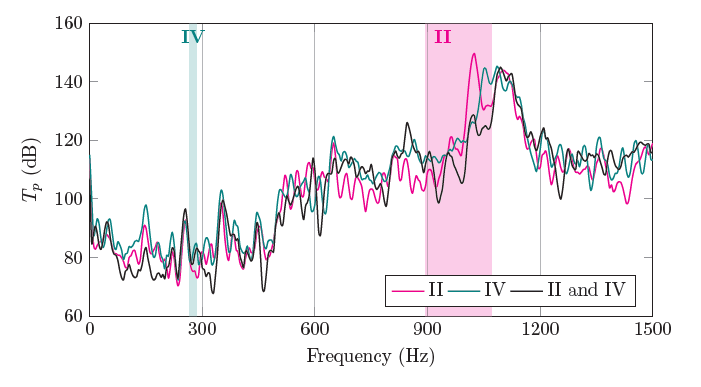
**Figure 6.17 Comparison between transfer functions obtained by hammering a monopile containing a reference cushion and a cushion D.**

****

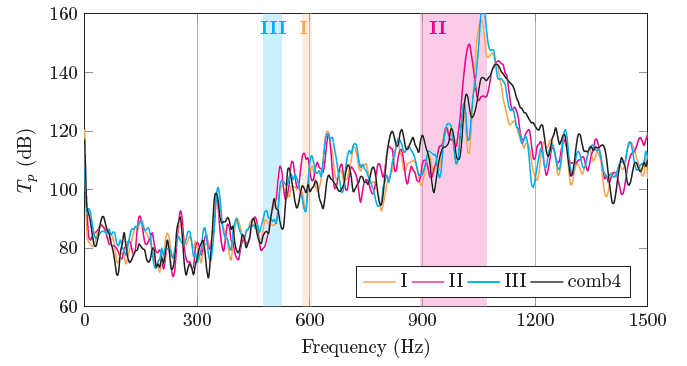
**Figure 6.18 Comparison among pressure transfer functions of cushions A (I), B (II), and comb1 (I and II).**

****

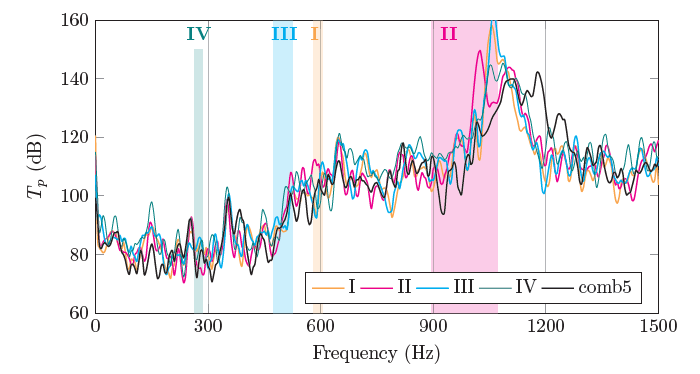
**Figure 6.19 Comparison among pressure transfer functions of cushions B (II), C (III), and comb2 (II and III).**

****

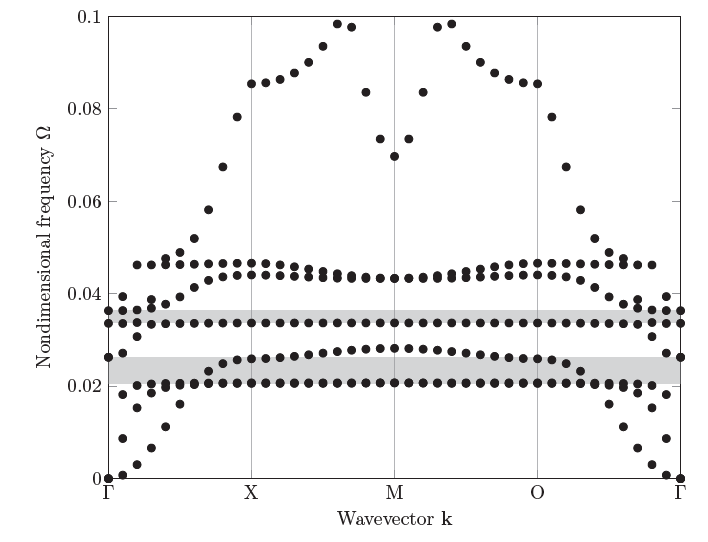
**Figure 6.20 Comparison among pressure transfer functions of cushions B (II), D (IV), and comb3 (II and IV).**

****

**Figure 6.21 Comparison among pressure transfer functions of cushions A(I), B (II), C (III), and comb4 (I, II and III).**

****

**Figure 6.22 Comparison among pressure transfer functions of cushions A(I), B (II), C (III), D(IV) and comb5 (I, II, III, and IV).**

****

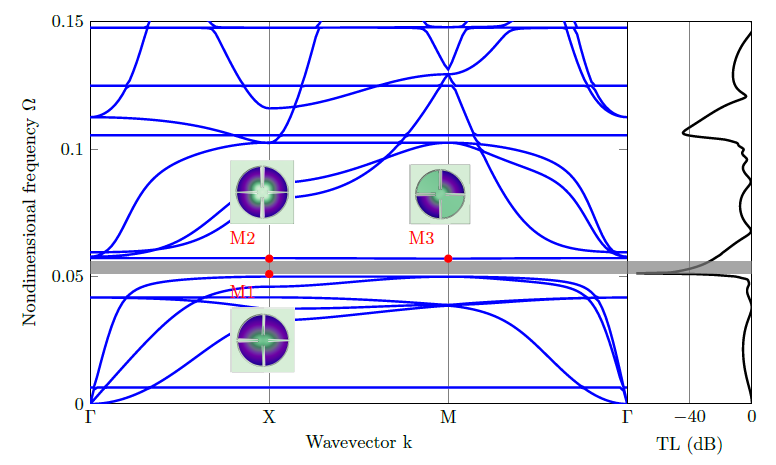
**Figure 6.23 Nondimensional dispersive curves of spiral resonator of type II.**

**Appendix A**

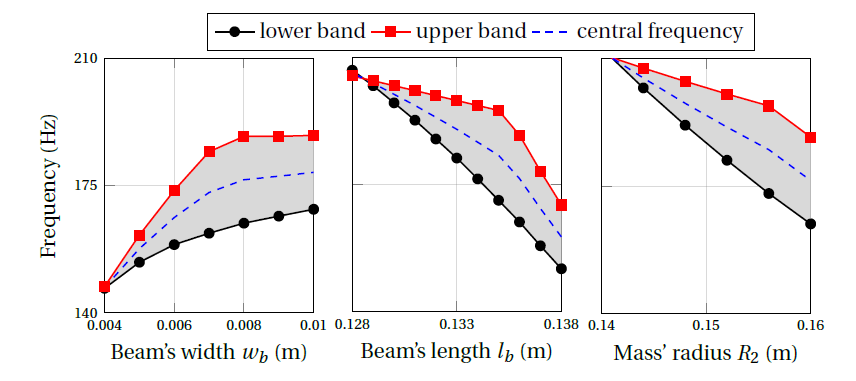
**Input parameters:**

Reference unit cell specifications (see Fig. 3.4 for geometric parameters):

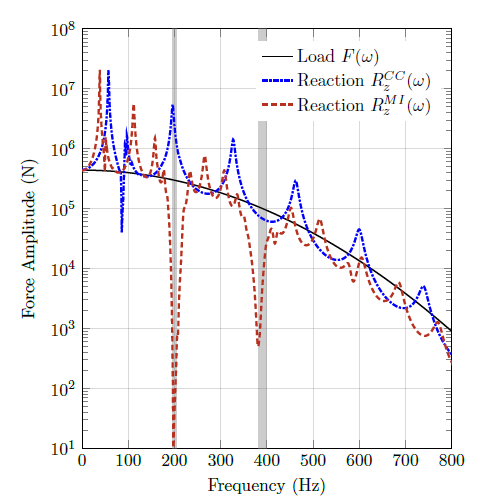
|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| a | R1 | R2 | wb | lb | lg | wg | h |
| 0.4 m | 0.42\*a | 0.4\*a | 0.02\*a | 0.99\*a | R2-0.08\*a | 0.05\*a | 0.23\*a |

****

**Figure A1. Band structure and transmission loss diagrams of unit cell presented in the table above.**

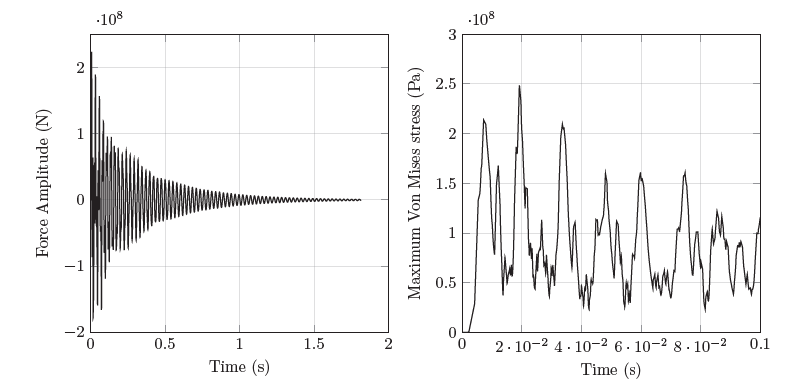
****

**Figure A2. Band gap variation with different values of beam’s width, length and mass’ radius.**

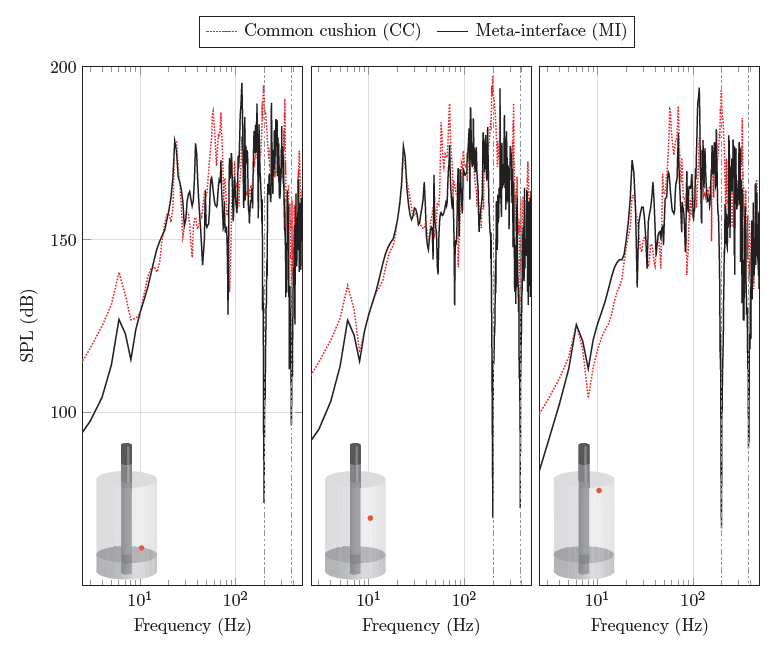
****

**Figure A3. Reaction forces obtained in the common cushion (CC) and the meta-cushion (MI).**

**Figure A3. Reaction forces obtained in the common cushion (CC) and the meta-cushion (MI).**

****

**Figure A4. Time signal of reaction forces obtained in the meta-cushion and maximum transient Von Mises stress.**

****

**Figure A6. Sound pressure level comparison between the common cushion and the meta-cushion at different water level heights.**