Graduate Students, Sciences and Engineering

Cantilever Beam Metastructure for Active Broadband Vibration Suppression

Ratiba Fatma Ghachi[1], Wael Alnahhal[1], Osama Abdeldjaber[2]

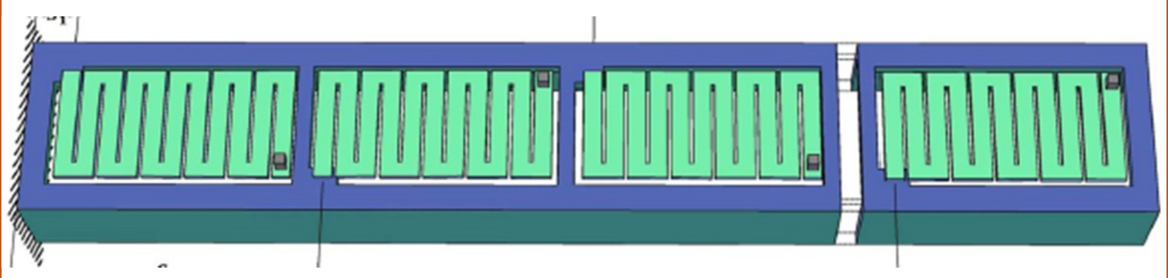
[1] Department of Civil and Architectural Engineering, Qatar University Doha, Qatar

[2] Department of Building Technology, Faculty of Technology, Linnaeus University Vaxjo, Sweden

ABSTRACT

This paper presents a beam structure of a new metamaterial-inspired dynamic vibration attenuation system. The proposed experimental research presents a designed cantilevered zigzag structure that can have natural frequencies orders of magnitude lower than a simple cantilever of the same scale. The proposed vibration attenuation system relies on the masses places on the zigzag structure thus changing the dynamic response of the system. The zigzag plates are integrated into the host structure namely a cantilever beam with openings, forming what is referred to here as a metastructure. Experimental frequency response function results are shown comparing the response of the structure to depending on the natural frequency of the zigzag structures.

Keywords: Vibration attenuation, Metastructures, Cantilever beam, Frequency-response-



Introduction

For decades a special interest has been given to vibration control (F. Casadei, Beck, Cunefare, & Ruzzene, 2012), noise reduction (Filippo Casadei, Dozio, Ruzzene, & Cunefare, 2010), and waveguiding (Vasseur et al., 2007). Passive vibration suppression is when a system is designed to operate independently from external force or controller.

An example of a single DF vibration absorber is if the desired system is modeled as a single degree of freedom oscillator. With the estimation of the stiffness and mass matrix, a single DOF absorber is chosen with stiffness and mass matrix that allows the resonant frequency to be reduced or eliminated (Abdeljaber, Avci, Kiranyaz, & Inman, 2017; "Engineering vibration," 1994).

Later, researchers expanded the concept of the single absorber to a series of distributed absorbers distributed along with the structure. These structures are mentioned here as metastructures as their behavior is reminiscent of this of matematerials.

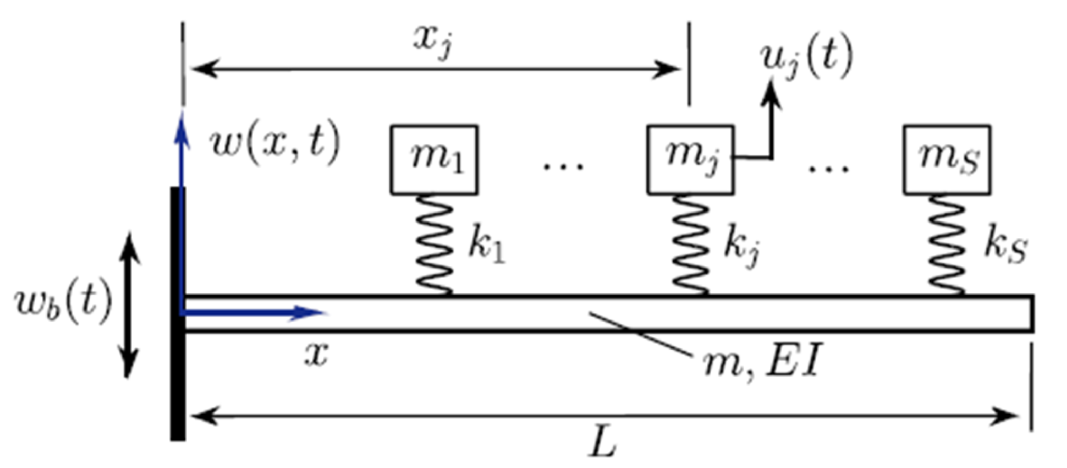
In this paper, we will report experiments on a cantilever beam including zigzags and present the gain in vibration attenuation compared to a cantilever beam of the same scale. The masses placed at the end of the zigzag approach the zigzags natural frequency to this of the beam which will change the overall system response.

The governing equation for the beam in physical co-

$$EI\frac{\partial^4 w}{\partial x^4} + m\frac{\partial^2 w}{\partial t^2} - \sum_{j=1}^{S} m_j \omega_{a,j}^2 u_j(t)\delta(x - x_j) = -m\ddot{w}_b(t),$$

The governing equation for each zigzag is:

$$\ddot{u}_j(t) + \omega_{a,j}^2 u_j(t) + \frac{\partial^2 w}{\partial t^2}(x_j, t) = -\ddot{w}_b(t).$$

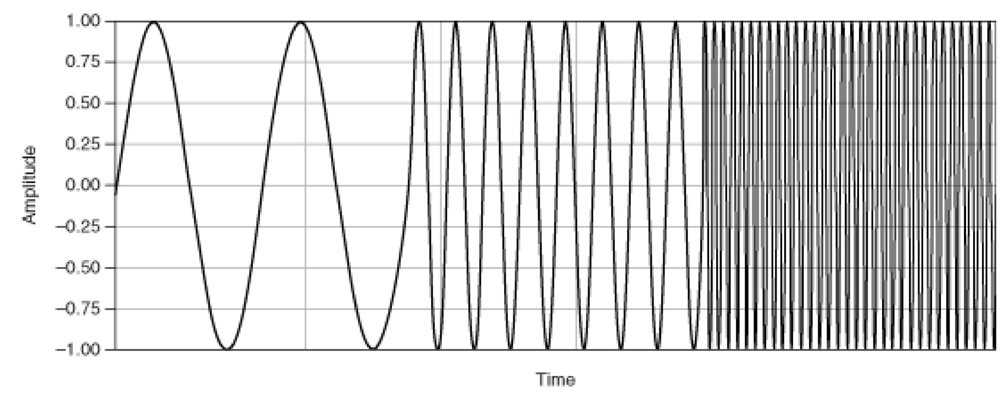


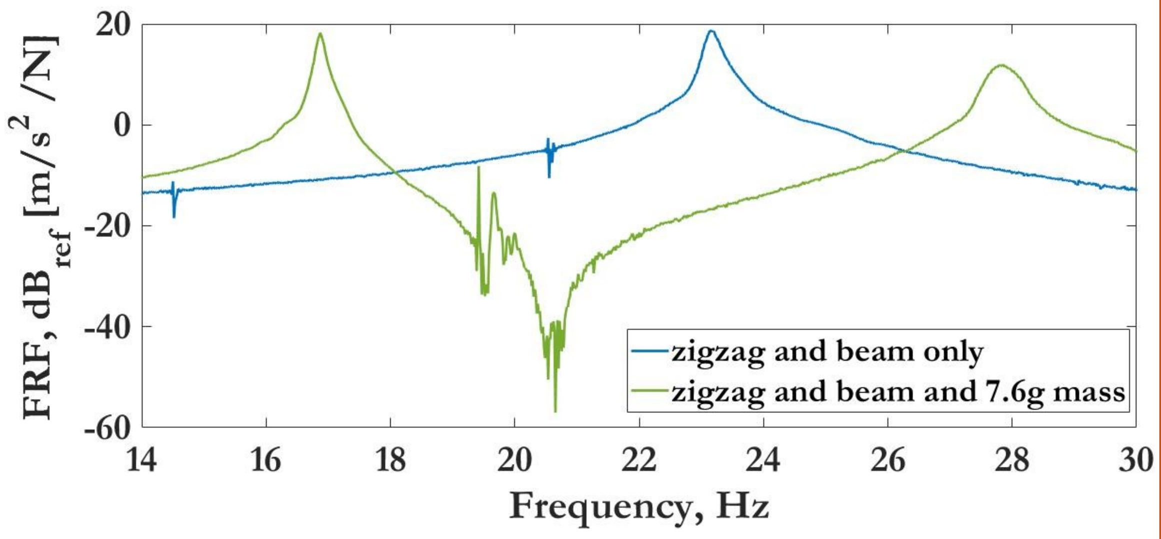
Material properties	Value	Units
Young's Modulus	69	GPa
Shear modulus	26	GPa
Density	2.7	g/cm^3
Length	75.5	cm
Base Width	5.21	cm
Leg Length	2.7	cm
Thickness	3	mm
Length	7.1	cm
Width	3.56	cm
Number of cut-outs	10	-

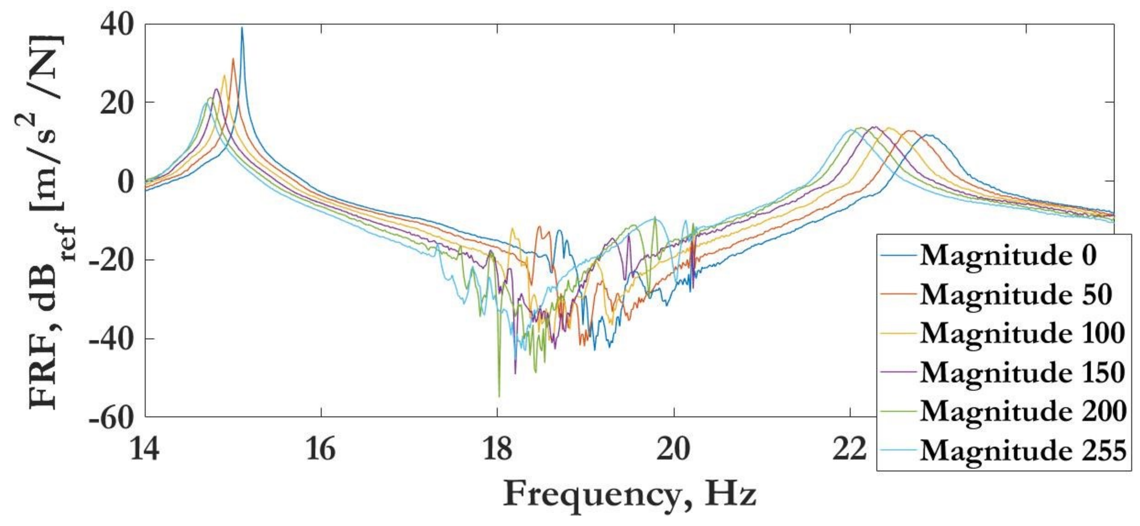
Zigzag Parameters	Value	Units
a-beam Length	5.21	cm
a-beam Width	1.24	cm
b-beam Length	1.73	cm
b-beam Width	0.89	cm
Thickness	1.9	mm
Number of a-beams	7	-

Experimental testing

The beam has been subjected to a sweep vibration at its base 1-50 Hz.

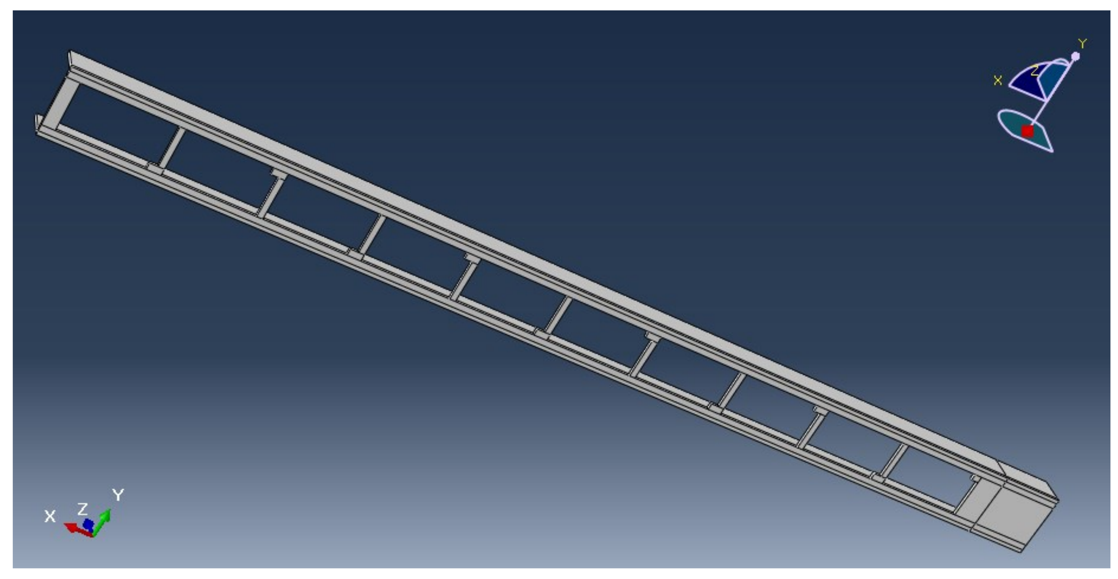


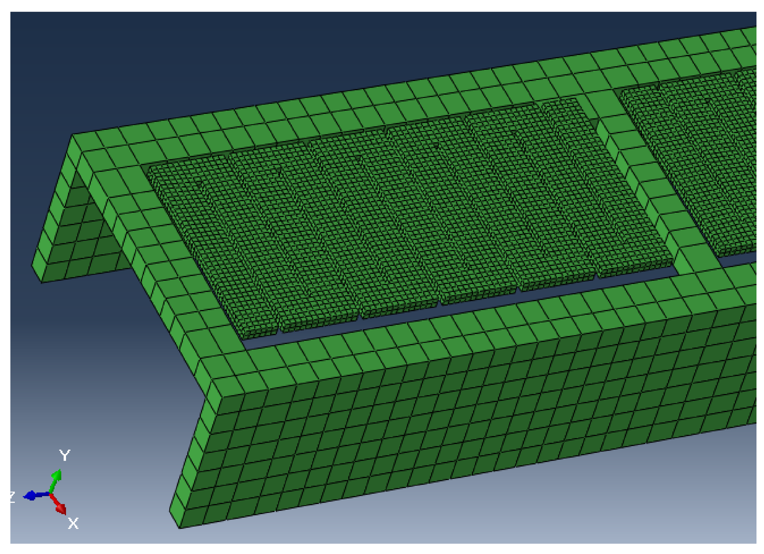




Conclusion

In this paper, we present an experimental investigation on the transmission behavior of a cantilever beam with inserts. Results show that the host with inserts system can split the peak response of the structure into two separate peaks rendering the peak frequency a low transmission frequency.





Acknowledgment

Financial support for this research was provided by Qatar National Research Fund (a member of Qatar Foundation) via the National Priorities Research Program, project number NPRP-8-1568 -2-666. The statements made herein are solely the responsibility of the authors, and they are not of the QNRF, Qatar University or Linnaeus University.