



## OPEN ACCESS

## EDITED BY

Mohammad Malikan,  
Gdansk University of Technology, Poland

## REVIEWED BY

Hossin Taghipoor,  
Velayat University, Iran

## \*CORRESPONDENCE

Chitaranjan Pany,  
✉ c\_pany@yahoo.com

## SPECIALTY SECTION

This article was submitted to Solid and Structural Mechanics, a section of the journal Frontiers in Mechanical Engineering

RECEIVED 23 March 2023

ACCEPTED 31 March 2023

PUBLISHED 06 April 2023

## CITATION

Pany C and Li G (2023), Editorial: Application of periodic structure theory with finite element approach. *Front. Mech. Eng* 9:1192657. doi: 10.3389/fmech.2023.1192657

## COPYRIGHT

© 2023 Pany and Li. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](https://creativecommons.org/licenses/by/4.0/). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

# Editorial: Application of periodic structure theory with finite element approach

Chitaranjan Pany<sup>1\*</sup> and Guoqiang Li<sup>2</sup>

<sup>1</sup>Structural Engineering Entity, Vikram Sarabhai Space Centre, Trivandrum, India, <sup>2</sup>Department of Mechanical & Industrial Engineering, Louisiana State University, Baton Rouge, LA, United States

## KEYWORDS

periodic structure, FEM, linear/non-linear, sound transmission, elastic/acoustic metamaterials, pressurized structures, multi-layered, curved shell structure

## Editorial on the Research Topic

[Application of periodic structure theory with finite element approach](#)

## Introduction

A periodic structure consists of repeating unit cells. From man-made multi-span bridges to naturally occurring atomic grids, periodic structures are present everywhere. Brillouin (1953) first used the wave propagation method to study the dynamics of periodic lattices. The ability of periodic configurations to create electronic bands in semiconductors and crystals is similar to the structural/acoustic bandgap of elastic media. Reinforced plate and shell structures are frequently used in a variety of structural applications, including bridges, ship hulls, decks, aircraft, and aerospace rocket/missile structures, which are examples of periodic structures. Mead (1996) presents a thorough overview of the available literature on the vibration analysis of periodic structures. In the areas of homogeneous/heterogeneous composite structures, waveguides, phononic crystals (PCs), acoustic/elastic metamaterials, vibration acoustic isolation, noise suppression devices, vibration control, directed energy flow, etc., this might result in great implementations. Periodic structures are also used to study the tunability (Zheng et al., 2019) of filter characteristics, such as required acoustic band gap, propagation, cut-off frequency, attenuation, and response direction. Health monitoring (Groth et al., 2020) and damage detection of these structures requires a good understanding of the propagation of elastic waves through such periodic structures. In particular, the effect of periodicity on the movement of electromagnetic waves (Pierre, 2010) has been extensively studied and they have been applied to many optical and electromagnetic devices (Bostrom, 1983).

The finite element (FE) theory-based numerical approach exhibits the most diversity and usefulness in modeling physical structures among the various numerical approaches. The theory of wave propagation in the periodic structure with FEM (PSFEM) is the goal of the study topic, and the numerical solution is based on the FE analysis of the unit cell of the structure. This numerical FE method enables high accuracy with very little computational effort and is a recommended option for predicting waves in one-dimensional and two-dimensional single waveguides (Orris and Petyt, 1974; Pany et al., 2002; Pany and Parthan, 2003a; Pany et al., 2003; Pany and Parthan, 2003b; Pany, 2022). The majority of published

works on periodic structures used in engineering try to create theoretical and numerical techniques to understand wave propagation behavior and its attributes, even though the fact that these phenomena are widely known.

This Research Topic presents the recent novel trends to study wave propagation in different forms of periodic structures and materials using numerical techniques and the three research articles published were contributed by eight authors. The three original articles can be broadly attributed to three subtopic areas.

## Sound transmission through baffled multilayered curved shells

One article (Parrinello et al.) focused on sound transmission and studied the acoustic behavior of multilayered and periodic baffled curved shells with a general configuration of homogeneous and heterogeneous periodic layers of diverse types (fluid, solid, and poroelastic). This article presents an improvement in the latter technique for finite long and baffled heterogeneous curved shells. A generalized TMM that allows for the modeling of heterogeneous periodic layers is used to represent the responses of the multilayered shell to the blocked pressure (excitation) while a two-dimensional BE (boundary element) model is used to evaluate the blocked pressure on the outer surface of the baffled shell. The presented work differs from their prior work in the calculation of the blocked pressure. The difference resulted from a plane wave excitation impinging on the cylindrical shell embedded in an infinite planar rigid baffle and in the use of a one-dimensional windowing technique to account for the impact of the finite length of the shell on the transmitted power.

## Non-reciprocal piezoelectric metamaterials with tunable mode shapes

One article in this topic focuses on metamaterials. The Baz presented a finite element modeling approach to demonstrate the effectiveness of controlled shaping of the mode shapes of piezoelectric metamaterials as an effective means of controlling the magnitude and direction of wave propagation along this class of metamaterials. Such features show that this approach makes it possible to break the reciprocal properties of metamaterials to create a class of acoustic diodes. This work differs from that of Zheng et al. (2019) where piezoelectric bistable shunting networks were used to introduce non-linearities and asymmetry along the wave propagation path. Such complexity in the control of the piezoelements can acquaint undesirable structural unstableness.

## References

- Bostrom, A. (1983). Passbands and stopbands for an electromagnetic waveguide with a periodically varying cross section. *IEEE Trans. Microw. Theory Tech.* 31 (9), 752–756. doi:10.1109/TMTT.1983.1131585
- Brillouin, L. (1953). *Wave propagation in periodic structure*. New York: Dover Publication. Available at: <https://www.worldcat.org/title/536614>.
- Groth, E. B., Clarke, T. G. R., Schumacher da Silva, G., Iturrioz, I., and Lacidogna, G. (2020). The elastic wave propagation in rectangular waveguide structure: Determination of dispersion

## FEM simulation of hydraulic press frame parts with pre-stressed by means of winding steel wires

In this topic, the Zhang et al. proposed a breakthrough in the pre-tightening stress analysis technology of winding steel wires double frames in the field of hydraulic presses. The wire bias effect on the frame is simulated by a method called cooling and pressurization (Lei et al., 2018).

This Research Topic on Application of Periodic Structure Theory with Finite Element Approach marks the recent advances and insights in the field of structural mechanics and the growing interest in academic and applied research. We hope that the topic is interesting with the rapid development of PSFEM approaches, and methods, for new potential applications in the fields of vibration control, seismic mitigation, composite structures, waveguides, metamaterials, PCs, sound transmission, etc. The reported advances may help researchers study and better understand periodic structure unit cell applications.

## Author contributions

CP did the write-up and compiled the contributions from all authors. GL checked the manuscript.

## Acknowledgments

We greatly appreciate the contributions from all authors and reviewers as well as the support of the editorial office of *Frontiers in Mechanical Engineering*.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

curves and their application in nondestructive techniques. *App. Sci.* 10, 4401. doi:10.3390/app10124401

Lei, Z., Xu, H., Zhang, B., Li, D. B., Wang, H. B., and Zi, B. (2018). Filament wound composite sleeves of permanent magnet motor rotors with ultra-high fiber tension. *Compos. Struct.* 204, 525–535. doi:10.1016/j.compstruct.2018.07.119

Mead, D. J. (1996). Wave propagation in continuous periodic structures: research contribution from Southampton, 1961–1995. *J. Sound Vib.* 190 (3), 495–524. doi:10.1006/jsvi.1996.0076

- Orris, R. M., and Petyt, M. (1974). A finite element study of harmonic wave propagation in periodic structures. *J. Sound Vib.* 33 (2), 223–236. doi:10.1016/S0022-460X(74)80108-2
- Pany, C., Parthan, S., and Mukherjee, S. (2002). Vibration analysis of multi-supported curved panel using the periodic structure approach. *Int. J. mech. Sci.* 44 (2), 269–285. doi:10.1016/S0020-7403(01)00099-6
- Pany, C., and Parthan, S. (2003a). Axial wave propagation in infinitely long periodic curved panels. *J. Vib. Acoust.* 125 (1), 24–30. doi:10.1115/1.1526510
- Pany, C., and Parthan, S. (2003b). Flutter analysis of periodically supported curved panels. *J. Sound Vib.* 267, 267–278. doi:10.1016/S0022-460X(02)01493-1
- Pany, C., Parthan, S., and Mukhopadhyay, M. (2003). Wave propagation in orthogonally supported periodic curved panel. *J. Eng. Mechanics* 129 (3), 342–349. doi:10.1061/(ASCE)0733-9399(2003)129:3(342)
- Pany, C. (2022). An Insight on the Estimation of Wave Propagation Constants in an Orthogonal Grid of a Simple Line-Supported Periodic Plate Using a Finite Element Mathematical Model. *Front. Mech. Eng.* 8:926559. doi:10.3389/fmech.2022.926559
- Pierre, H. (2010). Wave propagation in nanocomposite materials. *J. Electromagnetic Ana. and Appls.* 2 (7), 411–417. doi:10.4236/jemaa.2010.27053
- Zheng, Y., Wu, Z., Zhang, X., and Wang, K. W. (2019). A piezo-metastructure with bistable circuit shunts for adaptive nonreciprocal wave transmission. *Smart Mat. Struct.* 28, 045005. doi:10.1088/1361-665X/ab083c