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# Analysis of the size-dependent wave propagation of a single lamellae based on the nonlocal strain gradient theory

Farzad Ebrahimi*[1], Farin Zokaee[1] and Vinyas Mahesh[2]

[1]*Faculty of engineering, Imam Khomeini International University, Qazvin, Iran*
[2]*Department of Mechanical Engineering, Nitte Meenakshi Institute of Technology, Bangalore, India*

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**Abstract.** In the present article, the general wave propagation behavior of a single lamellae biological system was analyzed. The Lamellae is the main component of cortical bone. Its shape can be approximated by a cylindrical shell; so with using shell theories as displacement relations and the nonlocal strain gradient theory (NSGT) as constitutive relation was obtained the equation of motion. Using the NSGT leads to the effectiveness of scale parameter on equations of motion and the obtained results. The governing equations are derived by Hamilton's principles. The results are showing the variations of the overall trend of wave velocity toward wave vector have descending scheme and wave frequency against wave vector have ascending scheme; also were investigated effects of size and geometrical parameters on wave velocity and wave frequency. It was shown uptrend of types of wave velocities for wave vectors greater than $10^5$.

**Keywords:** bone; lamellae, osteon; wave propagation; size effect

## 1. Introduction

Surveying biological material from the perspective of engineering science extremely has been done to achieve: a) biomimetic material, b) displaying vital signs status c) improve functionality and elimination of defects of living organs; in the simple word, investigators are trying to incept from which be and optimized during millions of years or trying to show what those are, or trying to add something to biological structures to make a more optimized system. Mathematical analysis of biological structures has always been a favorite of researchers; as a better understanding of these structures and more importantly, it is possible to predict their behavior in different situations.

Bone as a biological structure is the solid compound of the skeleton of creatures and the part of the framework of the body, among duties of this member is, making strength in the body, protection of some tissues, etc. Bones are the place for the production of white blood cells and red blood cells. They are a source of minerals, in particular, calcium; bones transmit minerals whenever the body needs them. Most bones are composed of two parts: a) spongy bone, b) cortical bone. The outer part (cortical bone) of the rigid bone is made of collagen and calcium structure as hydroxyapatite and so on. However, there are other tissues such as blood vessel and nerve in it. This section of bones are made of units with the regular arrangement are known as the Haversian

*Corresponding author, Associate Professor, E-mail: febrahimy@eng.ikiu.ac.ir


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