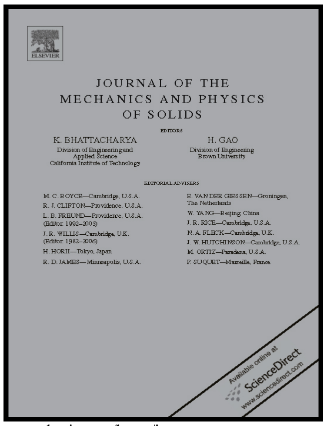
Author’s Accepted Manuscript



On the relationship between the dynamic behavior and nanoscale staggered structure of the bone

Mahan Qwamizadeh, Zuoqi Zhang, Kun Zhou, Yong Wei Zhang

PII: S0022-5096(15)00018-6
DOI: http://dx.doi.org/10.1016/j.jmps.2015.01.009
Reference: MPS2587

To appear in: *Journal of the Mechanics and Physics of Solids*

Received date: 4 September 2014
Revised date: 16 December 2014
Accepted date: 26 January 2015

Cite this article as: Mahan Qwamizadeh, Zuoqi Zhang, Kun Zhou and Yong Wei Zhang, On the relationship between the dynamic behavior and nanoscale staggered structure of the bone, *Journal of the Mechanics and Physics of Solids,* http://dx.doi.org/10.1016/j.jmps.2015.01.009

On the relationship between the dynamic behavior and nanoscale staggered structure of the bone

Mahan Qwamizadeh[1,2], Zuoqi Zhang[2], Kun Zhou[1*], Yong Wei Zhang[2†]

[1] School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore 639798, Singapore
[2] Institute of High Performance Computing, A*STAR, Singapore 138632, Singapore

ABSTRACT

Bone, a typical load-bearing biological material, composed of ordinary base materials such as organic protein and inorganic mineral arranged in a hierarchical architecture, exhibits extraordinary mechanical properties. Up to now, most of previous studies focused on its mechanical properties under static loading. However, failure of the bone occurs often under dynamic loading. An interesting question is: Are the structural sizes and layouts of the bone related or even adapted to the functionalities demanded by its dynamic performance? In the present work, systematic finite element analysis was performed on the dynamic response of nanoscale bone structures under dynamic loading. It was found that for a fixed mineral volume fraction and unit cell area, there exists a nanoscale staggered structure at some specific feature size and layout which exhibits the fastest attenuation of stress waves. Remarkably, these specific feature sizes and layouts are in excellent agreement with those experimentally observed in the bone at the same scale, indicating that the structural size and layout of the bone at the nanoscale are evolutionarily adapted to its dynamic behavior. The present work points out the importance of dynamic effect on the biological evolution of load-bearing biological materials.

[*] Corresponding author: Tel.: +65 6790 5499; fax: +65 6792 4062
Email address: kzhou@ntu.edu.sg
[†] Corresponding author: Tel.: +65 6419 1478; fax: +65 6463 0200
Email address: zhangyw@ihpc.a-star.edu.sg