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Dynamic Behavior of the Nanostructure of Load-Bearing Biological Materials

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Abstract : Typical load-bearing biological materials like bone, mineralized tendon and shell, are biocomposites made from both organic (collagen) and inorganic (biomineral) materials. This amazing class of materials with intrinsic internally designed hierarchical structures show superior mechanical properties with regard to their weak components from which they are formed. Extensive investigations concentrating on static loading conditions have been done to study the biological materials failure. However, most of the damage and failure mechanisms in load-bearing biological materials will occur whenever their structures are exposed to dynamic loading conditions. The main question needed to be answered here is: What is the relation between the layout and architecture of the load-bearing biological materials and their dynamic behavior? In this work, a staggered model has been developed based on the structure of natural materials at nanoscale and Finite Element Analysis (FEA) has been used to study the dynamic behavior of the structure of load-bearing biological materials to answer why the staggered arrangement has been selected by nature to make the nanocomposite structure of most of the biological materials. The results showed that the staggered structures will efficiently attenuate the stress wave rather than the layered structure. Furthermore, such staggered architecture is effectively in charge of utilizing the capacity of the biostructure to resist both normal and shear loads. In this work, the geometrical parameters of the model like the thickness and aspect ratio of the mineral inclusions selected from the typical range of the experimentally observed feature sizes and layout dimensions of the biological materials such as bone and mineralized tendon. Furthermore, the numerical results validated with existing theoretical solutions. Findings of the present work emphasize on the significant effects of dynamic behavior on the natural evolution of load-bearing biological materials and can help scientists to design bioinspired materials in the laboratories.

Keywords : load-bearing biological materials, nanostructure, staggered structure, stress wave decay
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