VANDERBILT
School *of* Engineering

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

Seminar

Friday,

March 29, 2024

12:15 pm

FGH 110

"WOODPECKER BEAK INSPIRED BIOLOGICAL SUTURE STRUCTURES FOR IMPACT & BLAST MITIGATION APPLICATIONS"

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ABSTRACT

Sutures are normally found in biological structures in the regions that require resisting high impact load. The inspiration for this research has come from the way woodpecker pecks the wood. The woodpecker beak structures have a soft suture structure made of collagen visco-elastic material surrounded by a hard Rampothica elastic layer. During pecking, the woodpecker's beak generates very high impact loads of the order of 1000g and the suture structure helps to filter high frequency load adaptively. From the mechanics point of view, the problem is a coupled elastic-viscoelastic analysis of inhomogeneous waveguides subjected to very harsh loading conditions. In this research, we have modelled the suture structure using both elastic and viscoelastic super convergent finite elements and performed extensive parametric studies to understand the way the sutures filter high frequency waves. Gradient based optimization studies are performed to determine the optimal suture parameters for maximum attenuation of the stress waves produced by beak pecking. The study shows some results that are non-obvious. Since these sutures are periodic, bandgap analyses were performed to understand the evaluation of stop bands in these structures. The final goal of the study is to use such suture structures in structural members in the context of impact and blast mitigation. Here, a hybrid suture structure is manufactured using 3-D printing technology that has optimized viscoelastic sutures sandwiched between two aluminium plates. This hybrid suture structure is then attached as face sheet in a foam core sandwich structure to understand its impact mitigation performance. Finally, in a practical application, these hybrid suture structures are mounted on a navy platform containing a heavy-duty motor rotating at very high speeds to study the shock mitigating properties.

BIOGRAPHY

Professor Gopalakrishnan's areas of research include Wave Propagation in complex media, Computational Material Science, Computational Mechanics, Smart Structures, Structural Health Monitoring, MEMS and Nano Composite Structures. He has puhlished 228 international journal papers in these topics (with an h-index of 54) and 6 graduate level textbooks and two undergraduate books. He is Editor-in-Chief of the ISSS Journal for Micro and Smart Systems and Associate Editor for two other journals: Smart Materials and Structures, and Structural Health Monitoring. His awards include: International Structural Health Monitoring Person of the Year, Fellow of Indian National Academy of Engineering, Fellow of Indian Academy of Sciences, and Associate Fellow of AIAA. In addition to extensive funding from the Government of India, he has attracted $10 M in funding from U.S. sources such as Boeing, Pratt & Whitney, Office of Naval Research, and the Air Force Office for Scientific Research.