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Ph.D. SEMINAR TALK - 2

Title: **Performance assessment of bio inspired additively manufactured cellular structure for energy absorption application**

Speaker: **Mr Pabitra Kumar Sahu(ME21D062)**

Biography of the Speaker:

Ph.D. Research Scholar for the Dept of Mechanical Engineering, IITM

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Venue: **https://meet.google.com/agn-jtwy-nrm**

Abstract

Growing demand for energy absorbing structures and efficient material use has inspired many cellular designs. To achieve high energy absorption and high strength with light weight, an ingenious solution is to learn how biological structures adjust their configurations to absorb energy without catastrophic failure. In this study, novel bio-inspired lattice structures derived from butterfly wings and bird feathers are proposed, designed, and experimentally evaluated under quasi-static loading conditions. Butterfly wing-inspired lattice structures (BFS) were fabricated using thermoplastic polyurethane (TPU) via fused filament fabrication (FFF), while rock pigeon feather-inspired lattice structures were modified into biaxially symmetric configurations and fabricated using acrylonitrile butadiene styrene (ABS) through the same fabrication technique.

A comprehensive parametric investigation was conducted to evaluate the influence of key design variables, including strut geometry (circular, hexagonal, and square), unit cell size, strut thickness, loading direction, inclination angles, and functional grading, on mechanical performance. The mechanical responses were quantified in terms of elastic modulus, compressive strength, plateau stress, energy absorption, and specific energy absorption. Results demonstrated that the BFS structures exhibited significantly enhanced energy absorption capacity, higher specific energy absorption, increased average plateau stress, and superior elastic modulus when compared to conventional bio-inspired lattice structures reported in the literature.

Cyclic compression tests further revealed excellent reusability and durability of the TPU-based BFS structures, which retained substantial energy absorption capabilities even after apparent structural failure. For bird feather-inspired lattices subjected to both in-plane and out-of-plane loading, distinct deformation behaviours were observed. Circular strut geometries exhibited superior performance under in-plane compression, whereas square strut geometries showed improved resistance under out-of-plane loading. The butterfly wing-inspired lattices displayed bending-dominated behaviour, while the bird feather-inspired lattices demonstrated stretch-dominated deformation characteristics.

Overall, this study highlights the strong potential of butterfly wing- and bird feather-inspired lattice structures for high-performance protective applications, including helmets, body armor, and footwear insoles, where an optimized balance of strength, stiffness, energy dissipation, and durability is required.

Keywords: Lattice structure, Additive manufacturing, Fused filament fabrication, Bio-inspired design, Energy absorption, Numerical simulation.