Structures

NASA Glenn is doing research in upgraded nanofiber matrices and their subsequent use in composites reinforced with conventional fibers, which has produced enhanced composite responses with up to two times the buckling load and comparable decreases in the first natural frequency. These are computed results only; however, some recent data indicate that the results are reasonable. The implication is that knowledge and judicious computational methods reduce or eliminate experimental data completely.

In a carefully planned extreme test inside Boeing’s Everett, Washington, plant, engineers bent the wings of a 787 Dreamliner ground-test airplane until the load was more than one-and-a-half times anything the jet will experience in service, the company says. By the end of the test, the wing had deflected upward from the horizontal by about 25 ft. This “ultimate load” wing stress test is a dramatic milestone in the process of obtaining FAA certification so the airplane can be used for passenger flights.

In a similar test in January 1995, Boeing bent the wings of the 777 beyond ultimate load until they broke in an explosive burst at 154% of the anticipated in-service maximum load, destroying the test plane. Unlike the traditional 777 aluminum wings, the Dreamliner’s wings are made of more flexible carbon-fiber-reinforced plastic and would be expected to keep bending far beyond the certification mark without breakage.

Could studying the structural properties of moth wings give the U.S. military a strategic edge on the battlefield of the future? Researchers at the Air Force Institute of Technology (AFIT) think so and hope that their studies will help to realize the Air Force’s vision of operating insect-sized micro air vehicles (MAVs) by 2030. These vehicles, essentially miniaturized flying robots, will be an order of magnitude smaller than current operational MAVs. Moreover, unlike their fixed-wing and propeller-driven predecessors, they will achieve flight by flapping their wings. In fact, if the vision is fully realized, they will so closely mimic the behavior of their biological inspirations that they will be able to carry out operations in plain sight. Having these insect-like characteristics will make them ideally suited for covert operations in urban, indoor, and tight corridor spaces. The AFIT/MAV team has set out to develop a high-fidelity structural model of an insect wing. When completed, this groundbreaking model could serve as a baseline for future design studies and ultimately shed new light on the nature of insect flight.

Advances in synthesis, manufacturing, and modeling techniques are continuing to drive nanocomposite research closer to use in aerospace structural applications. Research on carbon nanotube-, silica nanoparticle-, and nanoclay-reinforced polymer nanocomposites has brought insight into the clustering, damping, interfacial, thermal transport, electrical transport, and mechanical property characteristics of these materials. Work at MIT continues to focus on facile processes for creating large-scale bulk structured materials to take advantage (where possible) of nanoscale physics. Multi-scale methods in modeling crack-tip conditions have continued to improve understanding of the atomic-level behavior of metallic nanocomposites for use in aerospace structures. Exploratory research has begun developing pillared-graphitic structures for improved thermal transport in aerospace materials. Excellent thermal conductivity and mechanical integrity are provided in three dimensions.

AFRL, Trinity University, and the University of Kentucky are studying the FURL (flexible unfurlable and refurlable lightweight) solar sail payload to learn its capability for dozens of deployment-retraction cycles on-orbit. A thin membrane sheet is unfurled and refurled using a single rotational actuator coupled with a set of four self-deployable triangular retractable and collapsible booms attached to a perimeter spar structure, each constructed from a carbon-fiber-reinforced polymer. The full-scale 10-m² flight-like prototype has undergone environmental deployment testing, shape surveys, deployment kinematic measurements, and structural analyses in an effort to demonstrate that this payload is ready to serve as a propellant-free thrust source for Earth-orbiting spacecraft.

by Harry H. Hilton