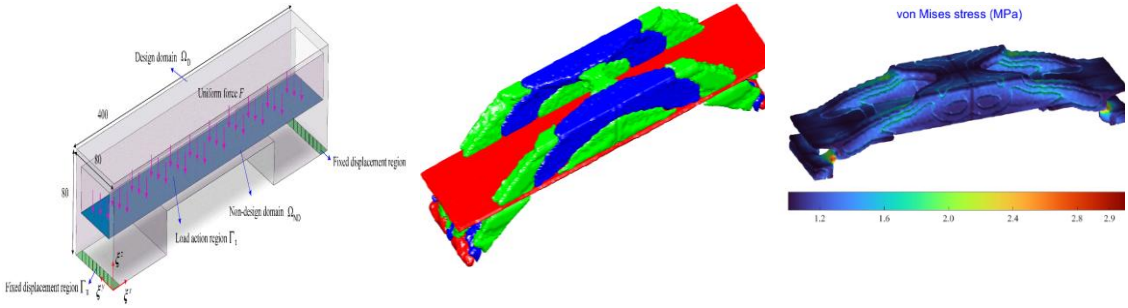
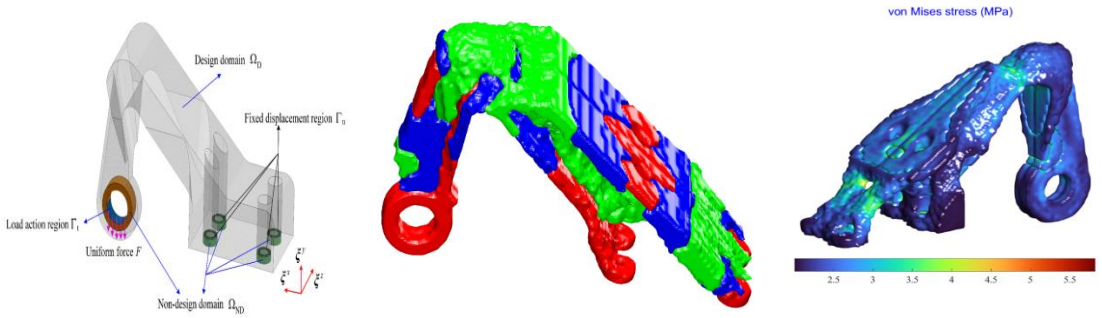
代表性科研成果介绍如下：

理论方面**针对结构轻量化设计需求，提出了单变量类型的多材料多尺度宏细观嵌套强耦合插值模型，建立了多相多尺度拓扑优化方法，并用于研制新型装备。**有关拓扑优化设计方法研究的文章发表在 Computer Methods in Applied Mechanics and Engineering(2025, 437:117749; 2024, 421:116774; 2021, 378:113727)等杂志上。提出的拓扑优化方法利用级数表达物理场，减少了优化变量，在降低计算成本的同时提高了数值计算稳定性和效率，而且具有能够在现有连续变量优化理论框架下进行求解分析等特点。

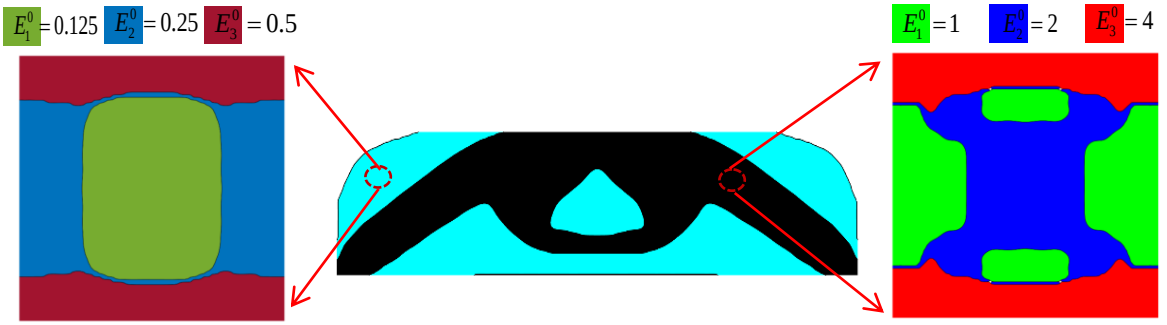


(a) 桥梁



(b) 航空支架结构

图 1 多材料刚强度拓扑优化设计工程应用案例

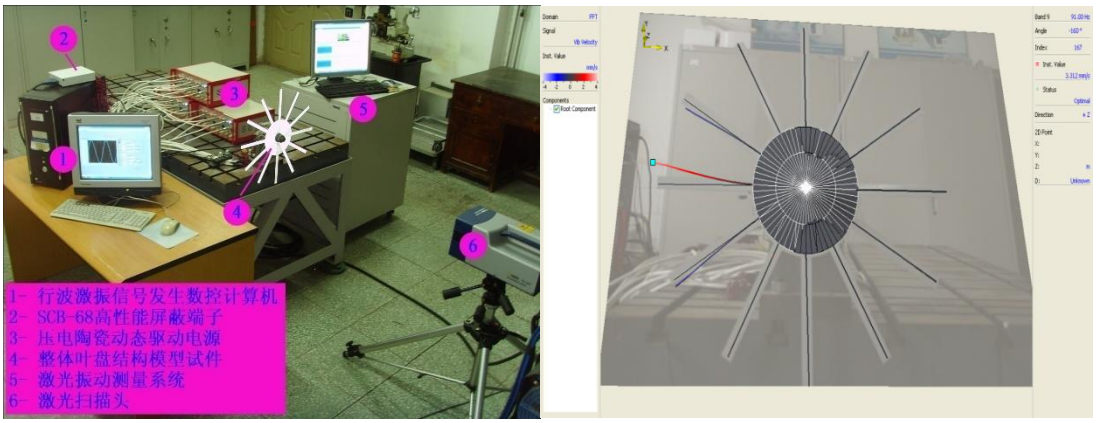


$$\tilde{\mathbf{D}}_1^H = \begin{bmatrix} 0.2970 & 0.0726 & 0.0000 \\ 0.0726 & 0.2538 & 0.0000 \\ 0.0000 & 0.0000 & 0.0840 \end{bmatrix}$$

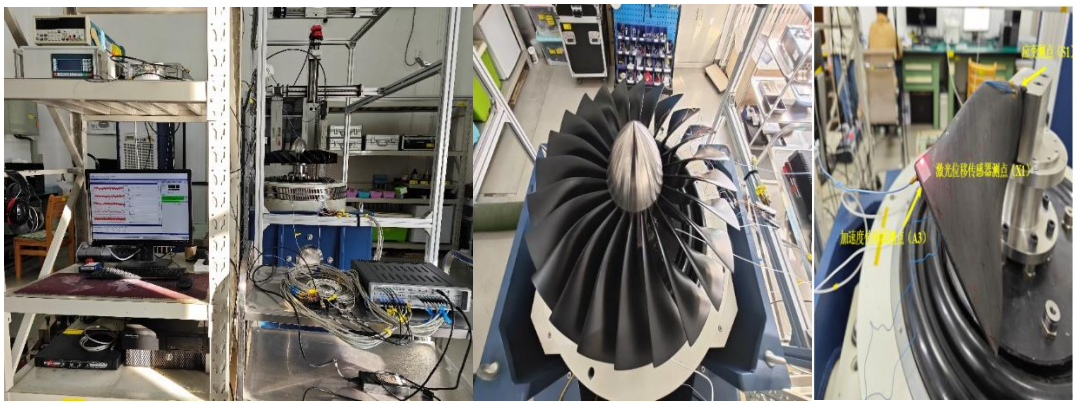
$$\tilde{\mathbf{D}}_2^H = \begin{bmatrix} 2.3904 & 0.5908 & 0.0000 \\ 0.5908 & 1.9286 & 0.0000 \\ 0.0000 & 0.0000 & 0.6885 \end{bmatrix}$$

图 2 结构多相多尺度拓扑优化设计

实验方面搭建了行波激振金属叶盘试验测试系统与铺层复材风扇叶片振动测试系统(如图 3 所示)，发展了结构动力学非接触测量技术与测试方法，**具有异形复材结构动力学试验研究基础。**采用高温模压工艺加工铺层复合材料风扇叶片/叶盘，开展了铺层复合材料叶片/叶盘结构的结构动力学试验，包含模态试验、随机激励以及瞬态冲击响应试验等，通过数值仿真和试验比较，系统地研究了铺层复材叶片的动力学性能(如图所示)。



(a)金属叶盘结构试验系统及典型金属失谐叶盘试验模态振型



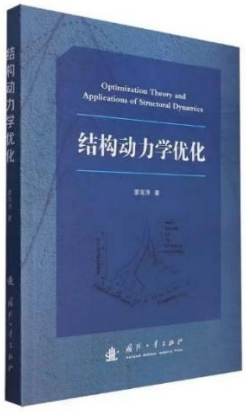
(b)复材结构动力学试验系统　(c) 铺层复材叶片/盘　　(d) 铺层复材叶片动力学试验

图 3 金属和铺层复材叶片/叶盘结构动力学试验

北京航空航天大学的白广忱教授发表在《航空动力学报》(2014,29,91-103) 的综述文章指出在失谐叶盘结构动力学实验方面的工作填补了国内空白:“**廖海涛等利用搭建的行波激励实验系统，**提出了预测失谐叶盘结构最大失谐幅值放大系数及最坏失谐模式的方法，…，**填补了国内关于失谐叶盘结构强迫响应试验的空白**”。

专著及章节

廖海涛，《结构动力学优化》，2024，国防工业出版社



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