Density-based topology optimization integrated with genetic algorithm for optimizing formability and bending stiffness of 3D printed CFRP core sandwich sheets

東京大学工学系研究科　機械工学専攻　柳本研究室

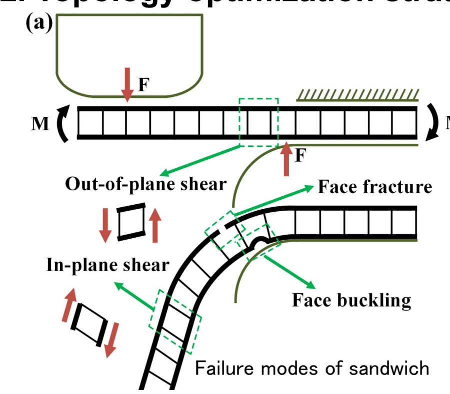
Chair of Engineering Materials
Graduate School of Engineering, The University of Tokyo
Jingwei Zhang and Prof. Dr.-Eng. Jun Yanagimoto

Chair of Engineering Materials

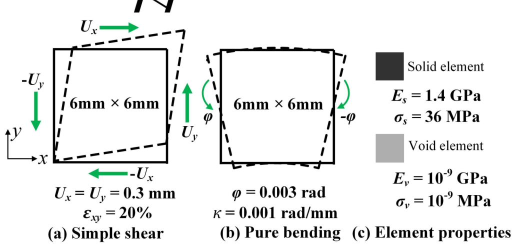
1. Introduction

To expand the application ranges of sandwich sheets from conventional 2D flat panel types to 3D complex shapes and simultaneously improve the specific bending stiffness, the density-based topology optimization was integrated with the multi-stage genetic algorithm (GA) to optimize the repeatable unit cell of the core structure of sandwich sheets. The failure constraints on core shear failure and face buckling were theoretically deduced to mathematically formulate the topology optimization problem, which was solved by the adaptive multi-stage GA to increase the possibility of generating physically meaningful and additively manufacturable topologies. The proposed approach is capable of designing formable sandwich sheets with improved bending stiffness.

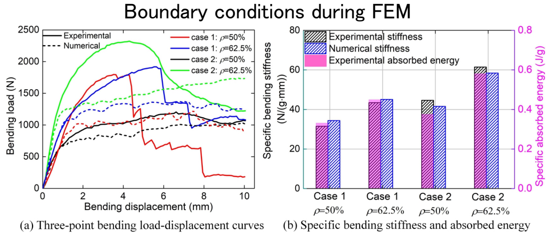
2. Topology optimization strategy



Failure modes of sandwich

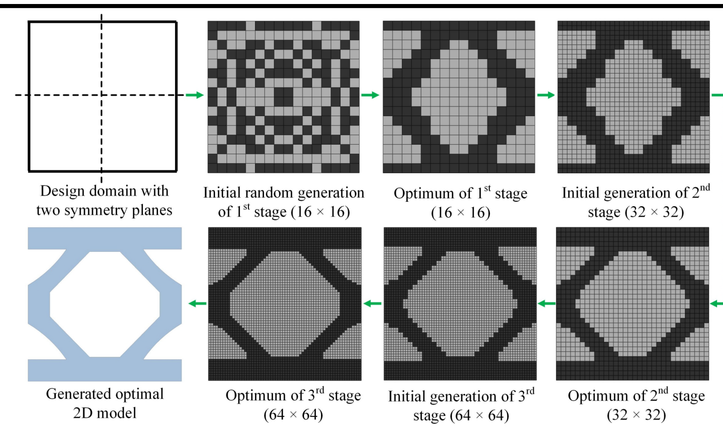


Boundary conditions during FEM



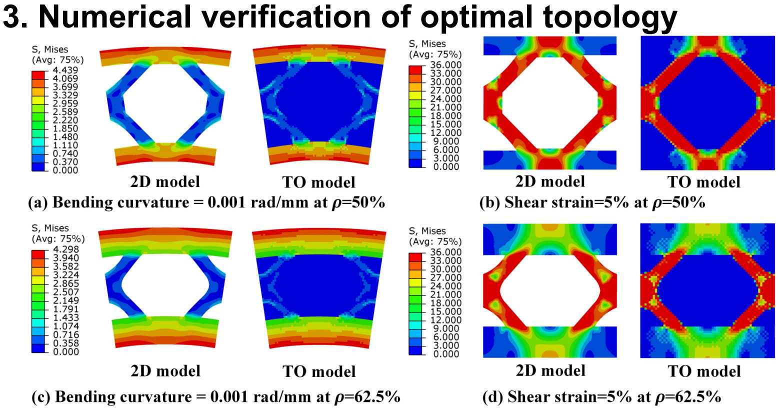
Mechanical properties of sandwich sheets

Multi-stage topology optimization



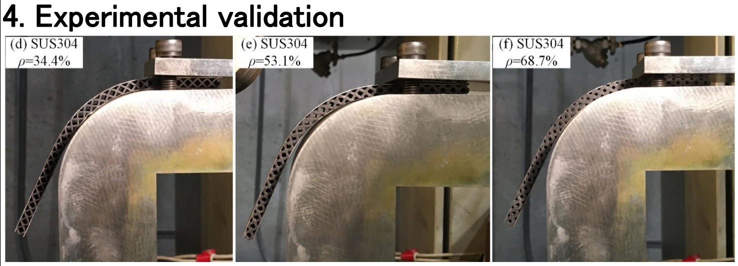
The design domain was progressively refined by a multi-stage search strategy to reduce the number of design variables.

3. Numerical verification of optimal topology



Verification of optimal topology

4. Experimental validation



The bending stiffness of sandwich topologies with the core density of 50% and 62.5% are improved by 41.58% and 41.49%, while the energy absorption capabilities are improved by 13.60% and 29.40% respectively. The topologically optimized sandwich structures can be well bent without any failure, which demonstrates the validity of the topology optimization method.

5. Conclusion

1. The theoretical core shear failure and face buckling constraints were deduced and incorporated in two topology optimization schemes to design the inner core topology for formable sandwich sheets.
2. L-bending tests show that potential failures including core shear failure, core–face sheet delamination and face buckling of most optimized sandwich topologies can be well suppressed.
3. The validity of the design strategy is demonstrated, that is, through the proposed topology optimization approach, the sandwich sheets with good formability and improved bending stiffness can be designed.
4. The proposed method can be expected to expand the applications of sandwich sheets with better formability and superior mechanical properties.