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Flexural Enhancement in Beetle-Inspired Sandwich Plates with a Large Height-to-Thickness Ratio Core

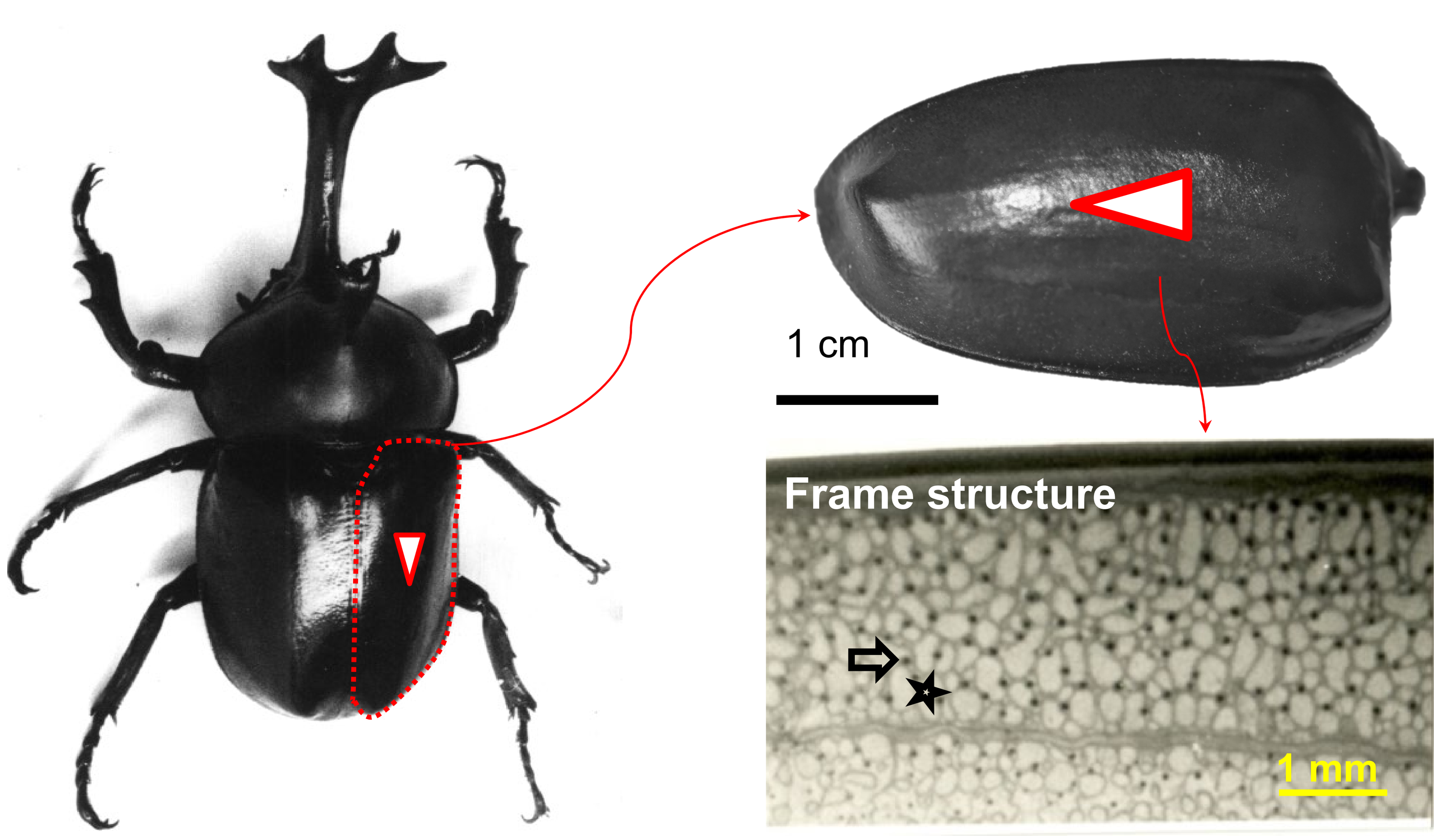
Yiheng Song 1,2*, Youlong Wang 2, Jie Chen 2, Chenwei Guo 2, Sihan Ruan 2

[1] School of Engineering, The University of Tokyo, 113-8656, Tokyo, Japan

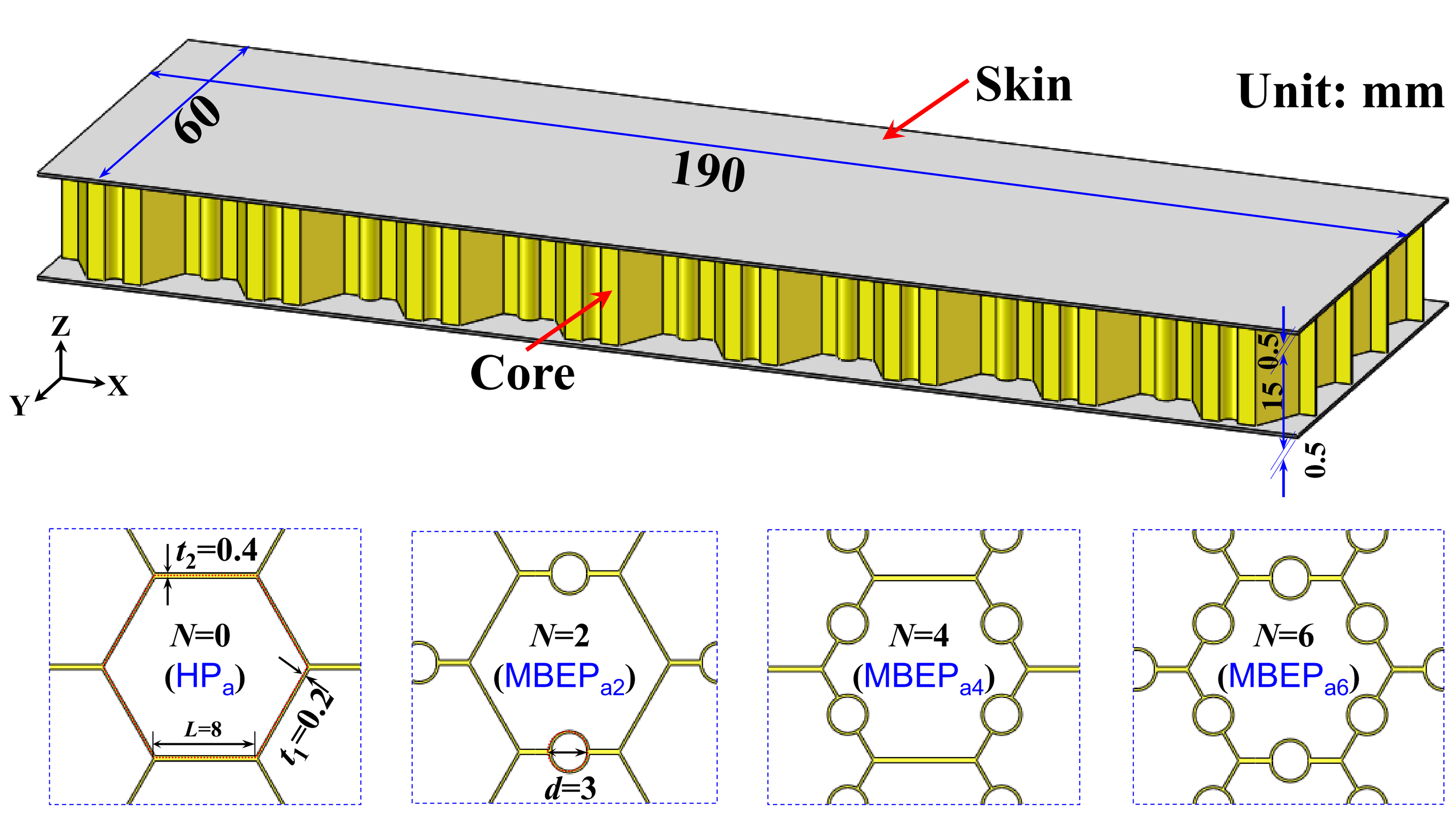
[2] School of Civil Engineering, Southeast University, 211189, Nanjing, P.R. China

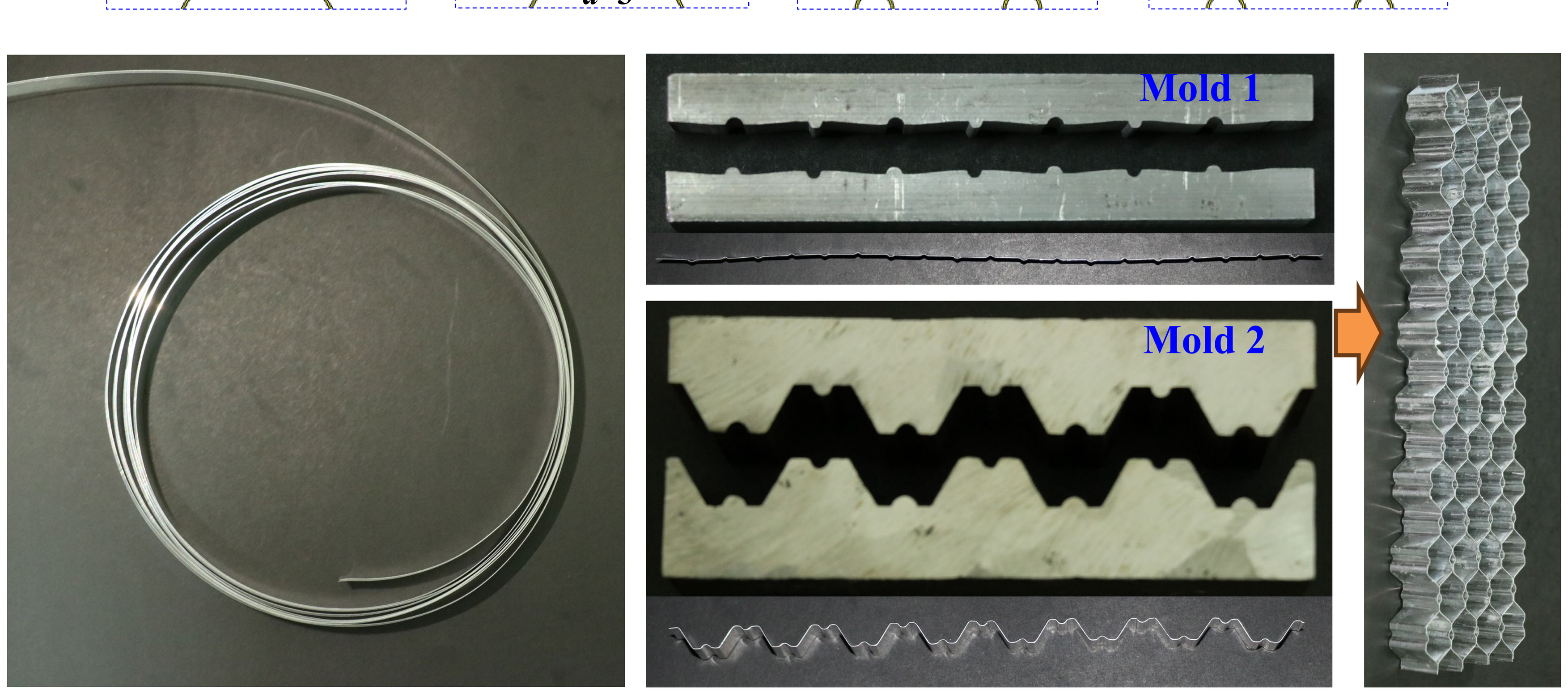
INTRODUCTION & AIM

Inspired by the natural world's engineering marvels, this study delves into the biomimetics of materials and structures, focusing on the remarkable structural mimicry of beetle elytron plates. Beetles, among Earth's most ancient organisms, have evolved lightweight yet robust elytra that conceal secrets of structural efficiency and durability. Mimicking the beetle elytron, we explore its analogous sandwich structure, akin to man-made aircraft wings, and its core's unique configuration—a honeycomb network reinforced with strategically placed trabeculae. This bio-inspired approach not only pays homage to the beetle's evolutionary refinement but also seeks to harness these natural designs for advanced engineering applications, embodying the essence of biomimetics in materials and structures.



SAMPLE DESIGN & PREPARATION

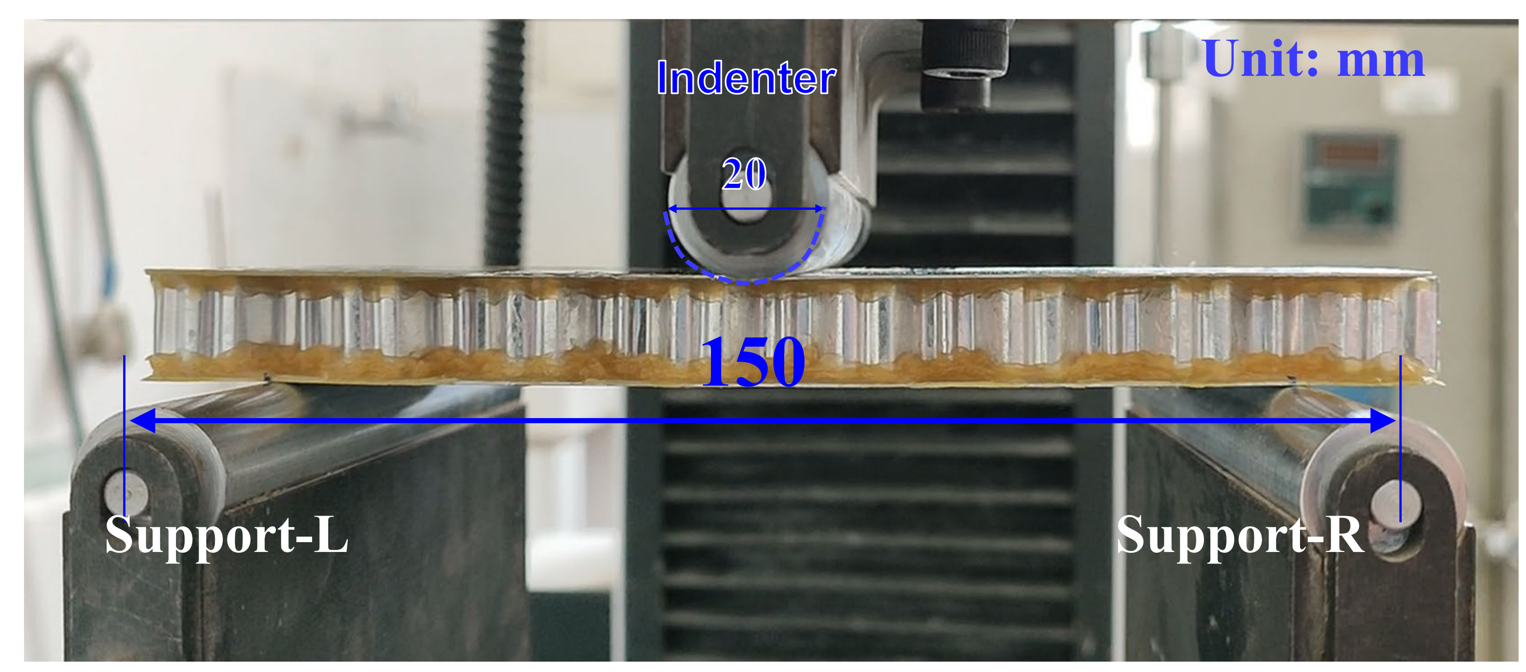




MBEP$_{a2}$

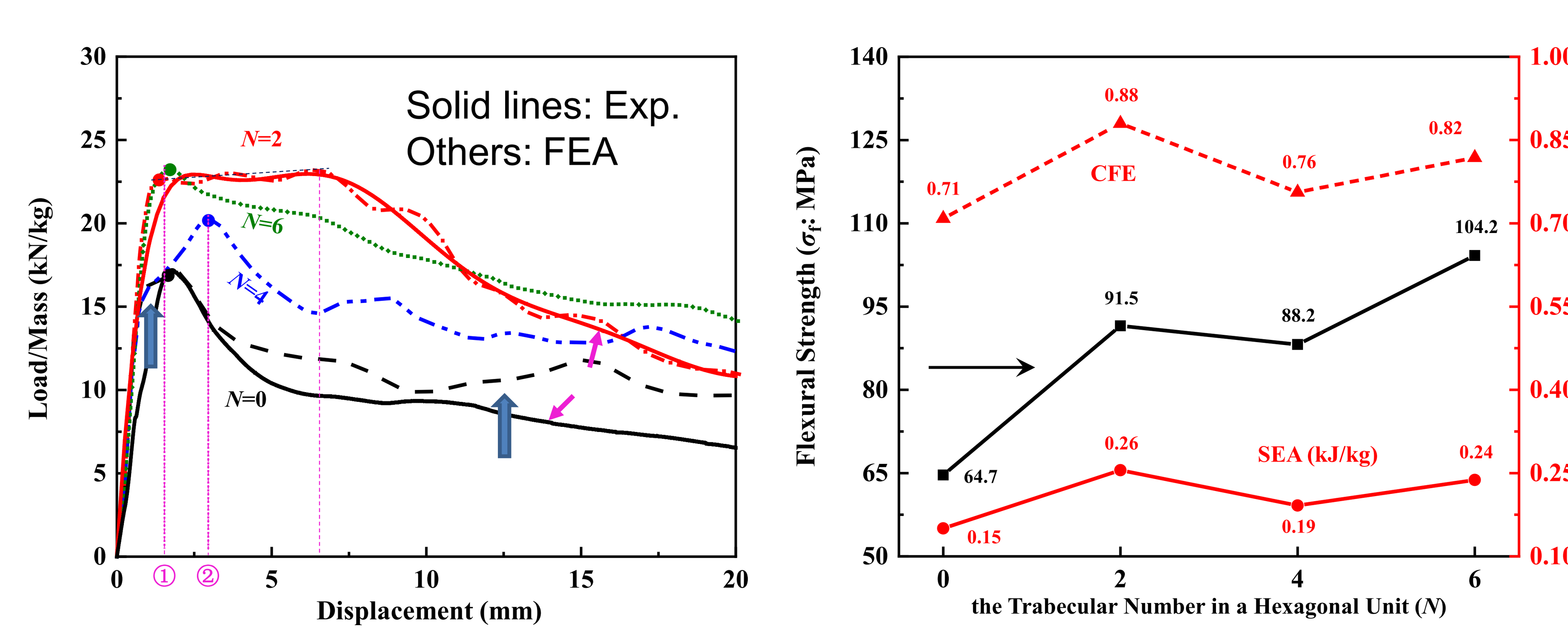
METHOD

The study employed a two-fold approach: quasi-static three-point bending tests on traditional honeycomb plate (MBEP$_0$) and bio-inspired MBEP$_2$ plate, followed by finite element analysis (FEA) for MBEP variants (N = 2, 4, 6).



RESULTS & DISCUSSION

MBEP$_2$ exhibited a notable 41.4% increase in flexural strength over traditional honeycomb plates. Contrary to expectations, higher N did not correspond to improved bending performance; instead, MBEP$_2$ outperformed others, including MBEP$_6$, with a distinct upward plateau on the load-displacement curve. Weak bending resistance was particularly noted near the upper plate of the first honeycomb wall across configurations, with deformation patterns varying with N. These findings suggest a complex relationship between trabeculae quantity and flexural performance, challenging simple linear assumptions.



CONCLUSION

The research uncovers previously unknown aspects of MBEP's flexural performance, highlighting its potential for engineering applications. The variation in trabeculae numbers and distributions offers insights into optimizing the material's mechanical properties for broader utilization in design and manufacturing.