STUDY ON SNAPPING-THROUGH BEHAVIOR OF BISTABLE COMPOSITE LAMINATE ACTUATED BY MFC

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1. INTRODUCTION

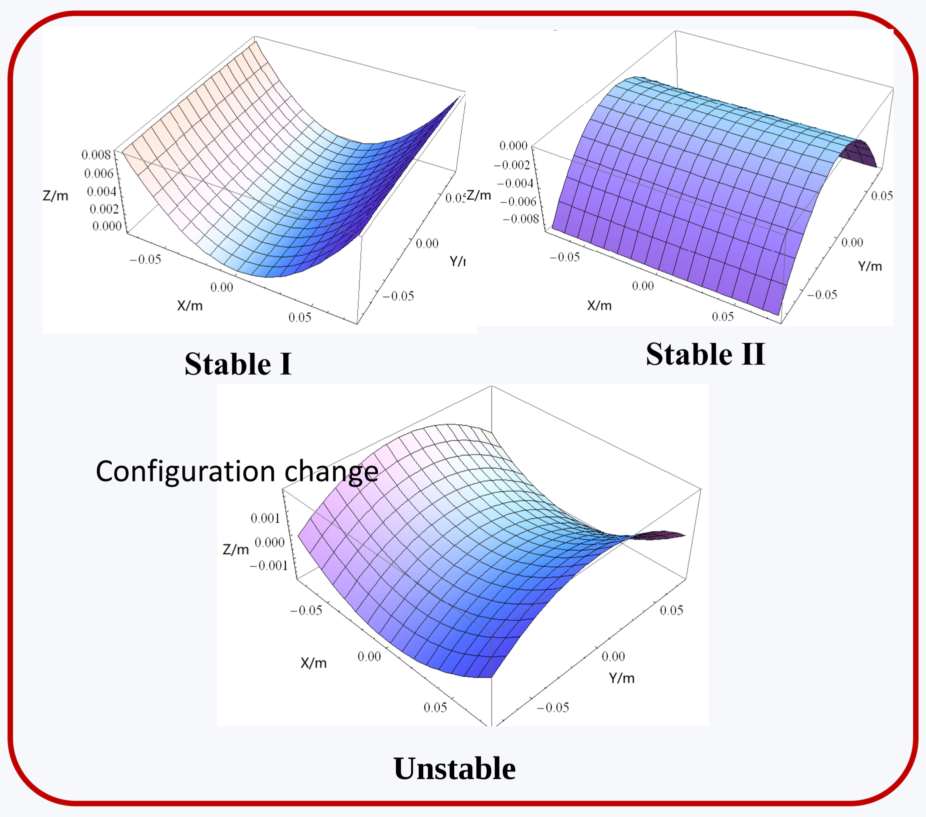
Deformable structures have been widely used in aerospace and other fields, but most of the traditional deformable structures use mechanical or hydraulic transmission to achieve deformation drive, which undoubtedly increases the mass and volume of the system and violates the requirements of lightweight. MFC, as an actuator, only needs to be used for the deformation process of bistable structure from one equilibrium state to the other, so continuous input energy is not required. The theoretical model of anti-symmetric bistable structure actuated by MFC is established in this paper. In the finite element simulation process, the effective driving part in the MFC is equivalent to a simple piezoelectric material, and the structural model of the [90/0] anti-symmetric bistable laminated plate actuated by the MFC is constructed. The actual actuating experiment of geometric size model is carried out. Finally, the overall configuration of the structure is determined, the snap-though process and the configuration results obtained by model calculation and experiment are compared. The minimum actuating voltage was measured by the experiment is 1370V, which is in good agreement with the finite element method.

2. Mathematical model of antisymmetric bistable plate

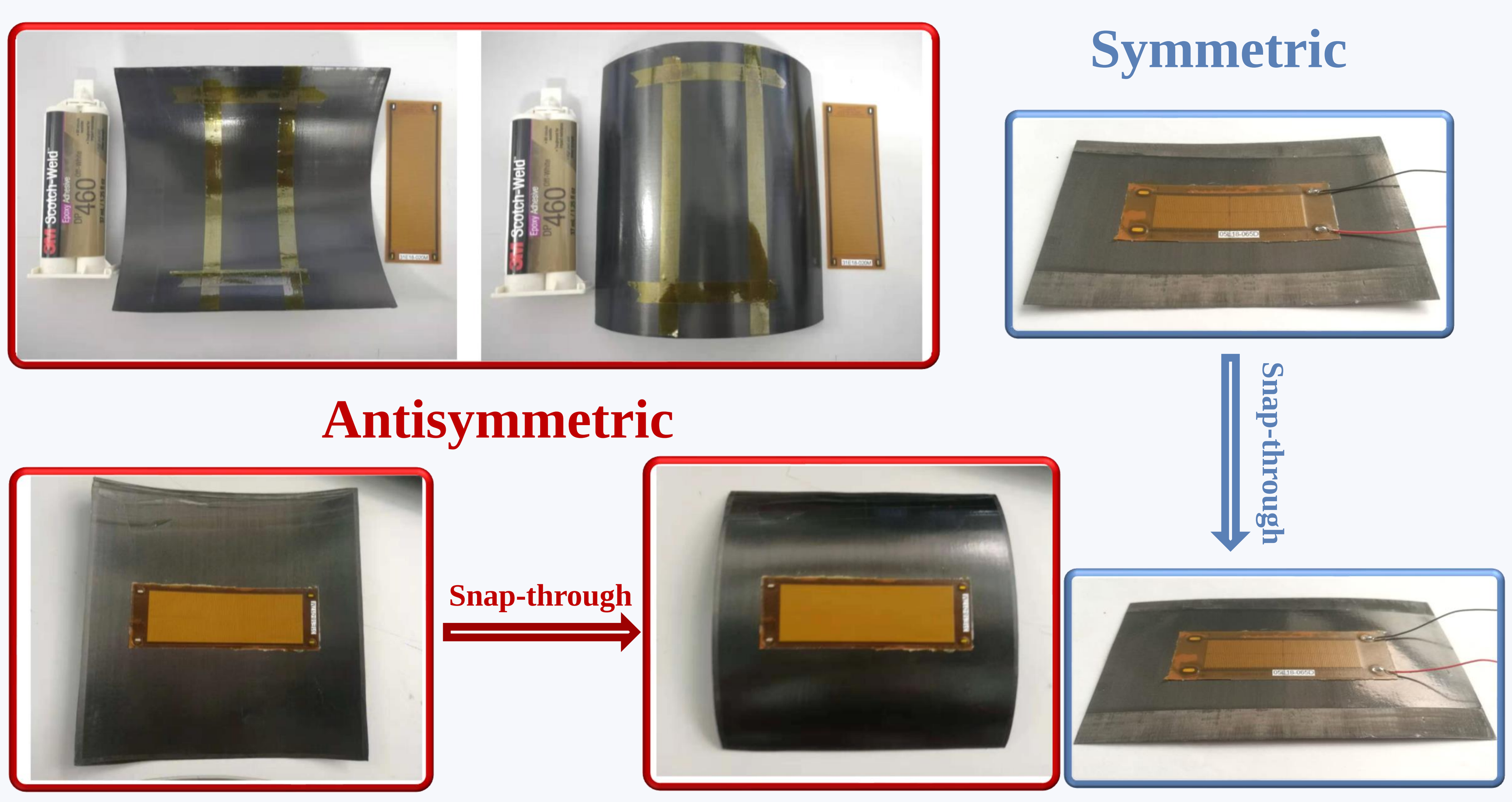
$$\Pi_1 = U_1 - W_t = \frac{1}{2}\int_V \left(\varepsilon_1^L\right)^T Q \varepsilon_1^L dV - \int_V {\varepsilon_t^L}^T Q \varepsilon_1^L dV$$

$$\Pi_2 = U_2^L + U_2^{MFC} = \frac{1}{2}\int_V \left(\varepsilon_2^L\right)^T Q^L \varepsilon_2^L dV + \frac{1}{2}\int_{V^{MFC}} \left(\varepsilon_2^{MFC}\right)^T Q^{MFC} \varepsilon_2^{MFC} dV$$

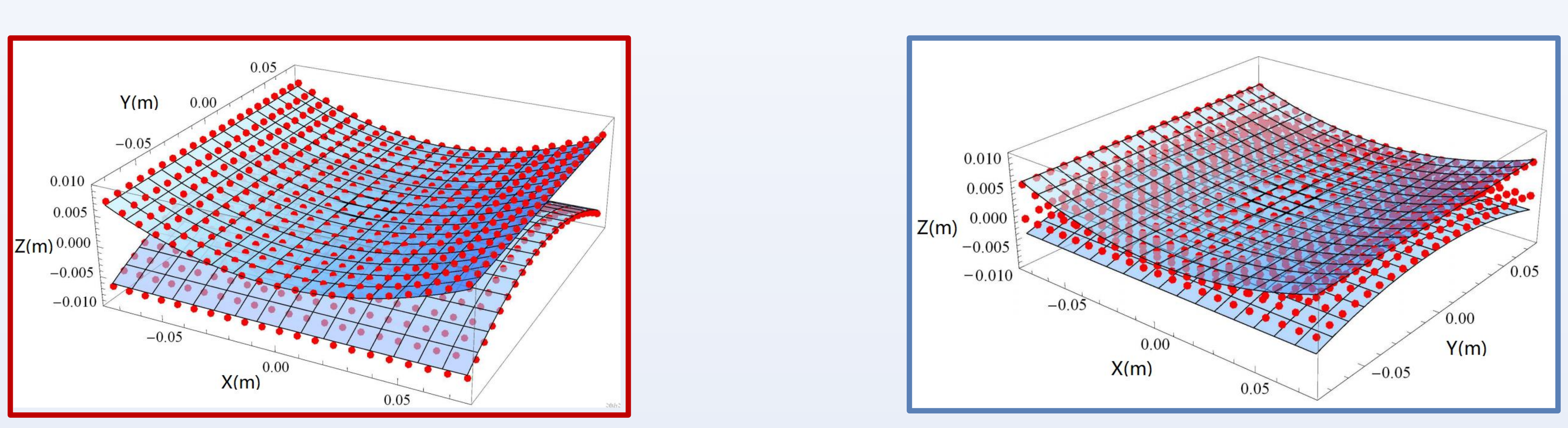
$$\Pi_3 = U_3^L + U_3^{MFC} - W_{el}^{MFC} = \frac{1}{2}\int_V \left(\varepsilon_3^L\right)^T Q^L \varepsilon_3^L dV + \frac{1}{2}\int_{V^A} \left(\varepsilon_3^{MFC}\right)^T Q^{MFC} \varepsilon_3^{MFC} dV - \int_{V^{MFC}} \left(\varepsilon_E^{MFC}\right)^T Q^{MFC} \varepsilon_E^{MFC} dV$$



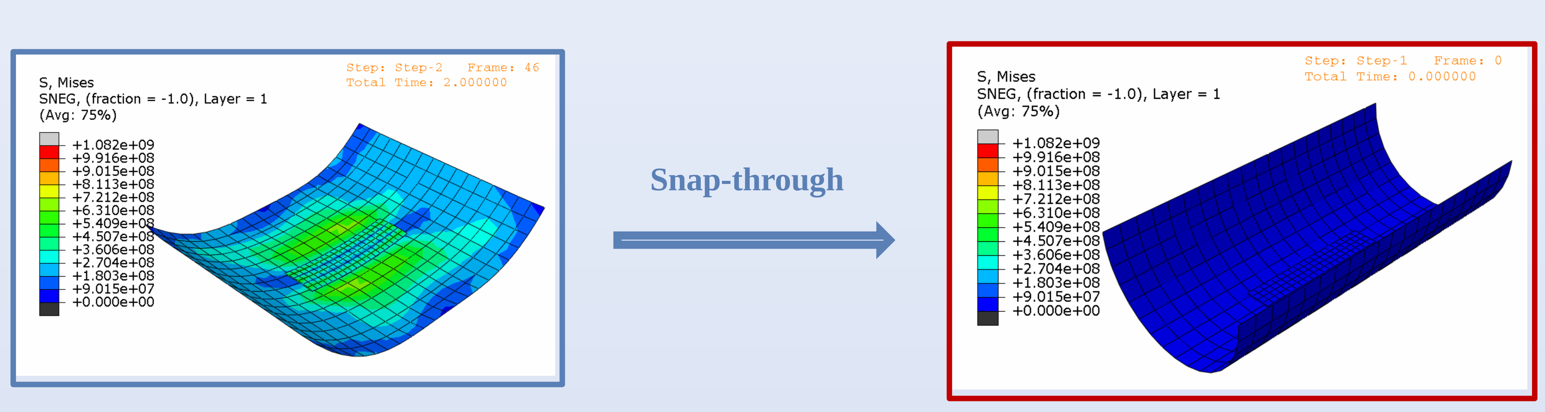
3. EXPERIMENTS



4. FINITE ELEMENT ANALYSIS

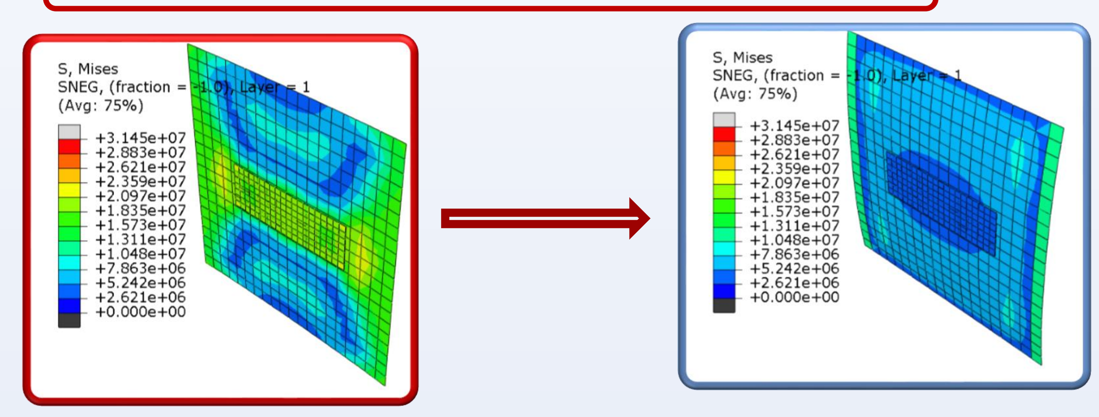


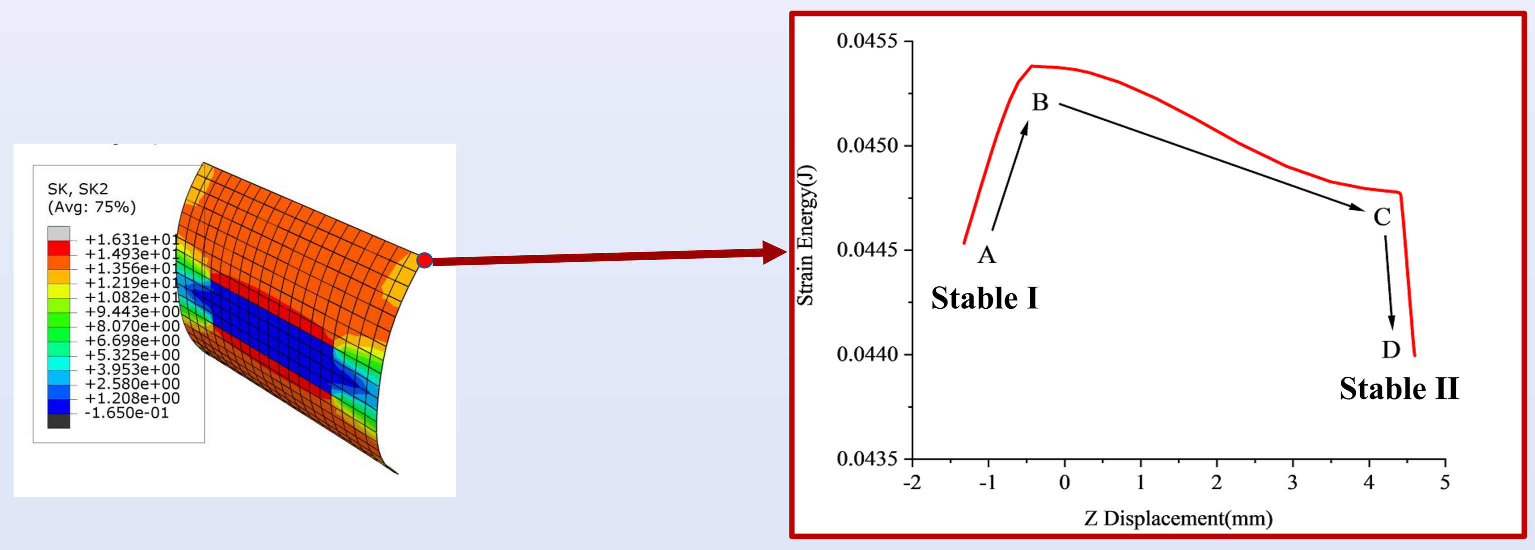
➢ Configuration change



Shell structure with initial curvature is driven by MFC

Antisymmetric bistable laminates is driven by MFC





Strain energy dynamic curve

6. CONCLUSIONS

- ➢ MFC can successfully drive antisymmetric bistable laminates, symmetric bistable laminates and cylindrical shells with initial curvature in one direction under the action of voltage load.
- ➢ The configuration mode of single-sided adhesive MFC will lead to the inconsistency of the two configurations of the bistable laminate, and the stability of the two configurations is also different. Configuration II is often better than configuration I.

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