

# Buckling of Thin-walled Cylinders with Diamond Patterns

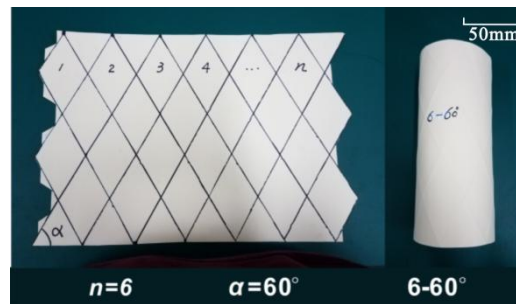
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**keywords:** thin-walled cylinders, buckling modes, snap-through

## Abstract

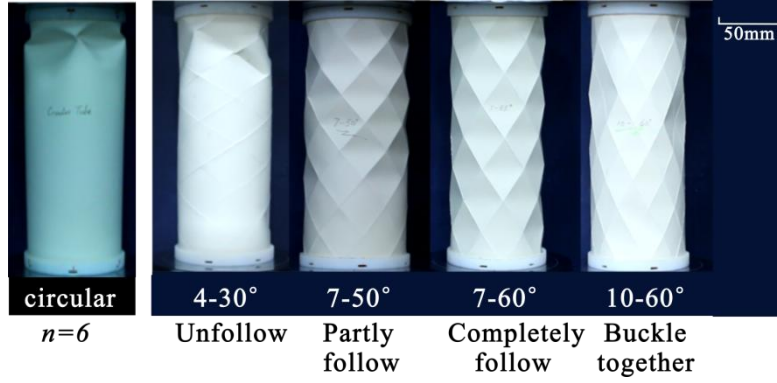
Thin-walled structures are widely employed in various engineering fields, due to their low cost, high manufacturability and excellent load-carrying efficiency. Subjected to axial compressions, thin-walled cylinders normally deform progressively into a ring mode or a diamond mode. However, elastic buckling of thin-wall cylinders, mainly due to loss of local stability, is difficult to be precisely predicted. In this paper, we designed a thin-walled cylinder, which has unfolded pattern embedded on the surface, with the aim of control its buckling behaviours.

Diverse planar diamond patterns were designed within a fixed A4-sized thin paper board with two variables, the number of circumferential lobes  $n$  and the slant angle  $\alpha$  (Figure 1). Each crease on the paper board was first folded back and forth, and then the paper board was rolled and glued to form a cylindrical shape. The cylinder was intentionally kept an unbuckled shape as also shown in Figure 1 before it was axially compressed.



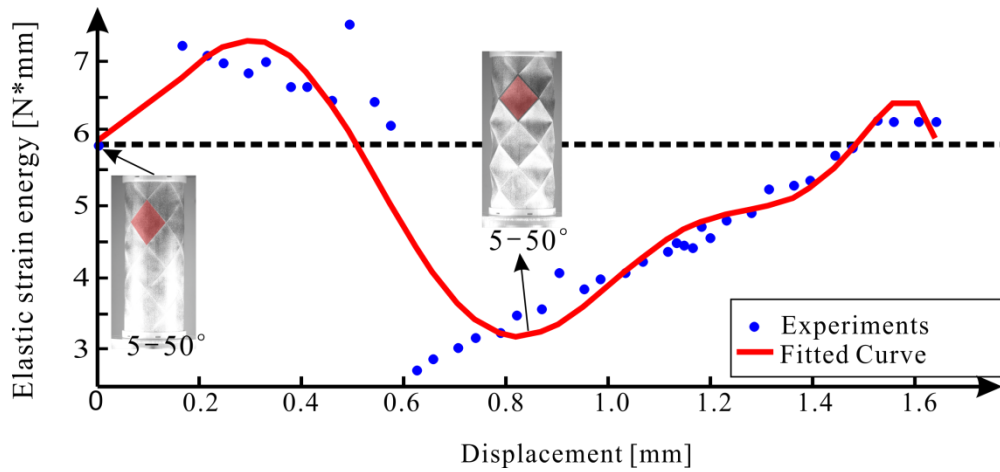
**Figure 1:** Geometry of the diamond-shaped pattern and a cylinder with pattern embedded on the surface.

A series of cylinders with varying geometric parameters were designed and manufactured, and quasi-static axial compression experiments were conducted to investigate the effects of pattern geometry on the buckling modes. Experimental results showed that four buckling modes were obtained as can be seen in Figure 2, compared with that of a cylinder without pattern ( $n = 6$ ). Moreover, when choosing appropriate  $n$  and  $\alpha$ , a thin-walled cylinder “completely followed” its pre-manufactured creases. In other words, its post-buckling configurations could be specifically controlled.



**Figure 2:** Buckling modes of a cylinder without pattern and cylinders with patterns.

In addition, the deformation process of the repetitive diamond-shaped lobes formed on the cylinders was studied in details through digital image correlation technique with a VIC-3D system. The elastic strain energy of a completely buckled unit, highlighted in red in Figure 3, was calculated from the experimental results (blue dot in Figure 3), and a curve was obtained by curve-fitting method. The results indicated that a snap-through phenomenon occurred during the buckling of the lobe.



**Figure 3:** DIC test results of 5-50° model and plot of Elastic strain energy vs. displacement.

To summarize, pre-fabricated diamond patterns on thin-walled cylinders can initiate a series of buckling modes. By using the proposed method, it is possible to pre-design the buckled configurations of a cylinder upon specific requirements.