LOCAL BUCKLING OF AN ULTRA-LIGHTWEIGHT COMPOSITE TRUSSES UNDER BENDING

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Summary. Due to its advantages on weight savings, ultra-lightweight composite trusses have been developed for aerospace application as long span supporting structures. The flexural behavior of these new composite truss structures are both experimentally and numerically studied in this paper. Local buckling of the ribs is identified as the main failure mode under three-point bending.

1 INTRODUCTION

Structural weight of large fiber reinforced polymer composite trusses can be further saved by integrity technology of design and manufacture. A new ultra-lightweight composite truss structure has been developed as the next generation of long span supporting structures for aerospace applications. Generally, these composite trusses are integrally manufactured by continuous filament winding and no extra connection components are used for truss ribs. All the ribs are made of continuous and unidirectional fibers reinforced polymer composites. Moreover, manufacture process directs the majority of their strength axially along the truss ribs so that the truss ribs are intrinsically stiff, strong and tough [1]. Mechanical behaviors of these composite trusses have been investigated under compression, tension and torsion [2]. Little works have been done on flexural performance. That is the gap this paper seeks to cover.

2 EXPERIMENT AND NUMERICAL ANALYSIS

A triangular cross section, glass fiber/epoxy composite truss is integrally fabricated by continuous filament winding. As shown in Figure 1, the truss structure is defined by five main geometric parameters: total length $L=6m$, bay number $N=18$, outer diameter of triangular cross section $D=348mm$, longitudinal rib diameter $d_1=8.5mm$ and helical rib diameter...
$d_2=5.2\text{mm}$. Total weight of this truss specimen is 5.3kg. Three-point bending test is conducted for the composite truss specimen. Both loading and deflection measuring point are set at the middle cross section of truss. Load and deflection data are recorded synchronously during the whole test process. Nonlinear finite element analysis is also performed. Both the experimental and numerical results are plotted in Figure 2.

3 RESULTS AND DISCUSSION

As shown in Figure 2, both the experimental and numerical load-displacement curves are of bilinear and a turning point is included. During the test, local buckling of the composite ribs can be observed near the turning point $(S_t, L_t)$. $L_t$ is suggested to be the ultimate load in design. Structural stiffness $k$ (slope of the first linear part of the curve) can be obtained by $L_t/S_t$. The difference of $L_t$ and $k$ between experimental and numerical results is less than 7%. The turning point $(S_t, L_t)$ hereby can be treated as the most significant structural responses of this composite truss under three-point bending. Local buckling of the ribs is the main failure model for the composite truss.

4 CONCLUSIONS

Local buckling of the composite ribs is identified as the main failure model for the ultra-lightweight composite truss under three-point bending by both experiment and nonlinear finite element analysis. Numerical results are well validated by experimental data. A bilinear load-displacement curve and its turning point are obtained. Both the ultimate load and flexural stiffness of the composite truss are derived from the turning point data.

REFERENCES