16th International Conference on Composite Structures
ICCS 16
A. J. M. Ferreira (Editor)

BUCKLING ANALYSIS OF ANISOGRID COMPOSITE LATTICE CONICAL SHELLS

Evgeny V. Morozov*, Alexander V. Lopatin† and Vladimir A. Nesterov†

* School of Engineering and Information Technology
University of New South Wales at the Australian Defence Force Academy
Canberra, ACT 2600, Australia
e-mail: e.morozov@adfa.edu.au

† Department of Aerospace Engineering
Siberian State Aerospace University
Krasnoyarsk, Russia
e-mail: lopatin@krasmail.ru

Key words: Composite lattice structures, Buckling analysis, Anisogrid conical shell.

Summary. *The buckling behaviour of anisogrid composite lattice conical shells under axial compression, transverse bending, pure bending, and torsion is investigated. The effects of varying the lattice structure parameters on the buckling loads and behaviour of lattice shells are examined using finite-element analyses.*

1 INTRODUCTION

Conical anisogrid composite lattice shells made from carbon fibre reinforced plastic (CFRP) are extensively used in various applications, such as rocket interstages and payload adapters for spacecraft launchers (see Fig. 1) due to their high structural and mass efficiency [1]. The lattice shells are composed of curvilinear helical and circumferential (hoop) filament wound ribs made of a unidirectional composite material. They are capable of resisting the intensive loadings exerted during the launch and injection into orbit phases. Since the buckling is one of the foreseeable modes of failure in these cases, the buckling analyses have been performed for the shells subjected to axial compression, transverse and pure bending, and torsion.

2 MODELLING AND BUCKLING ANALYSIS

The modelling and buckling analyses were normally performed for composite cylindrical lattice shells using either continuum models that employ various modifications of rib smearing techniques [1] or finite-element methods [2]. Buckling of the conical lattice shells subjected to axial load was analysed using finite-element technique by Hou and Gramoll [3]. The anisogrid structure was modelled as a frame assembled from straight segments of the ribs neglecting their actual curved shape.

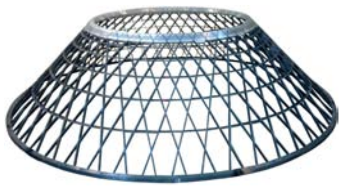

Figure 1: Anisogrid composite lattice spacecraft adapter (Courtesy of ISS-Reshetnev Company)

In this work, the lattice conical shells are modelled as three-dimensional frame structures composed of the curvilinear ribs subjected to tension-compression, bending and torsion. Modelling and analyses have been carried out using COSMOS/M [4]. The automated model generator was developed to simulate geometry of the naturally twisted helical ribs.

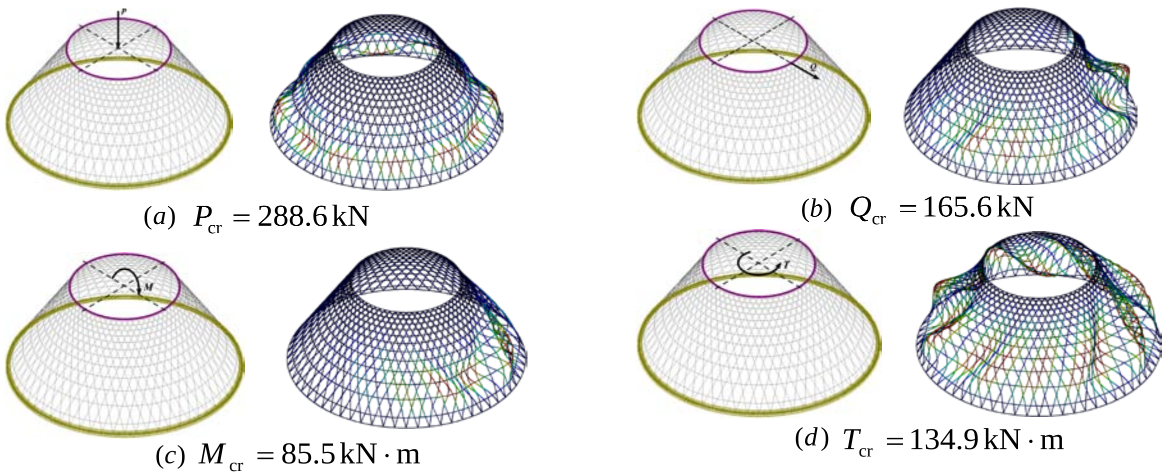

Figure 2: Buckling modes: (a) compression; (b) transverse bending; (c) pure bending; (d) torsion

The buckling analyses have been performed for the conical shells subjected to axial compression, transverse loading, pure bending and torsion. The shells have the diameters of the bottom and top sections $D = 1.6\,\mathrm{m}$ and $d = 0.8\,\mathrm{m}$, respectively, and height $H = 0.6\,\mathrm{m}$. The ribs of a 5x5 mm square cross-section are made of CFRP having the modulus of elasticity, $E_1 = 100\,\mathrm{GPa}$. The number of helical ribs in one helical direction is 64 and the helical angle at the bottom section $\phi = 15^{\circ}$. The buckling forms and corresponding critical loads obtained from the finite-element analyses are shown in Fig. 2.

REFERENCES

[1] V.V. Vasiliev and A.F. Razin. “Anisogrid composite lattice structures for spacecraft and aircraft applications”. *Compos. Struct*. 76, 182-189 (2006).

[2] E.V. Morozov, A.V. Lopatin and V.A. Nesterov. “Finite-element modelling and buckling analysis of anisogrid composite lattice cylindrical shells”. *Compos. Struct*. 93, 308-323 (2011).

[3] A. Hou and K. Gramoll. “Compressive strength of composite latticed structures”. J Reinf Plast. Compos. 17(5), 462-483 (1998).

[4] COSMOS/M user guide. Structural Research and Analysis Corporation (2003).